To: Argyropoulos, Paul[redacted]
From: Larry Schafer
Sent: Fri 9/27/2013 12:53:44 PM
Subject: Follow up on Biodiesel Meetings (RFS 2014 RVO)
Biodiesel GGH Reduction in Billions of Pounds and other Stats revised LCF 2013 YTD (9-19).xlsx
BW response to NERA RFS - short version - 9_17 (2).docx
OMB Economic Summary of Increased Biodiesel Production.docx
ABF Economics Waste Grease and Oils Study FINAL.docx
Global Renedering Information 2012 (April 2013).pdf
LMC_NBB Current and Future Supply of RFS2 Q and non-Q oils.pdf
Copy 2 of LMC_US Biodiesel Impact Study_Results for calendar years 2011-2014.xls
Outline OMB Meeting (9-19).docx
Final - Biodiesel Savings to the Consumer (BE +LS2)4.docx

Paul,

Late Last week, we met with OMB relating to the 2014 RVO for Biomass-based Diesel.

May we schedule a follow up meeting for the week of October 7th with Chris Grundler (and your small team) with our team of Anne Steckel, Lindsay Fitzgerald and me?

Attached is the information we provided to OMB at the meeting.

As we discussed, we already have a 1.7 to 2.0 billion gallon marketplace and our current RVO is 1.28.

We are asking for an increased RVO for Biomass-based Diesel to at least 1.7 billion gallons.

We understand that OMB doesn't particularly care if we have a large or small market (or for that matter a large or small RVO) and we know they care about the cost of the program.

On the issue of cost, the choice to be made by OMB is one of "how to fill the Advanced Biofuels Program?" It can be filled with domestic biodiesel or it can be filled with imported sugar cane ethanol. Both renewable fuels will have RIN costs attached to it, but at the end of the day if they increase the RVO to 1.7 billion gallons for Biomass-based Diesel, then the program will be $50 million less expensive (attached is a 30 page analysis discussing this point)

-

-- This is a NEW Study which we did not have available when we last met with you.

-

OMB is also concerned about the benefits of using biodiesel. Which is covered in Part II of the outline and we have outlined here:

Direct Benefits when moving from an RVO of 1.28 to 1.7 for Biomass-based Diesel

1. Direct Jobs = 1,890
2. Energy Security = $61.4 million
3. OMB Social Cost of Carbon = $136 million
4. Greenhouse Gas Emissions Reduction = 8 billion pounds
5. Direct House Hold Income: $96,057,000
6. Direct Economic Impact: $2,009,700,000
7. Total Cost Savings: $50 million

Finally, OMB wants to better understand the costs of biodiesel – the costs of production and the costs to the consumer -- we did a good job in explaining this issue and have repeated that discussion below.

Biodiesel is saving consumers (truck drivers) money at the diesel pump – because "discretionary blenders" are able to buy biodiesel at prices lower than the diesel rack price. The lower biodiesel price is then passed on to consumers.

Discussion points on the cost of production of biodiesel.

How much does it cost to produce? What does the marketplace look like? Based on historical discussions we have had with your team, it seems you believe that biodiesel is dramatically more expensive than petroleum diesel. So we are going to deal with that issue directly.

Biodiesel is a cost-effective renewable alternative to petroleum diesel that, with help from the Renewable Fuel Standard (RFS), is saving diesel consumers money at the pump. Each gallon of RFS-qualified biodiesel is accompanied by a RIN credit. The value of that credit, which is traded on the open market, is factored into the value of each gallon of biodiesel. This added value allows producers to sell biodiesel at a lower price to fuel distributors or fleet managers, who can then pass along savings to consumers.

The "cost of production" for biodiesel is fairly straightforward, mostly tracking to the cost of the feedstock used to produce it (Prices taken from Sept. 25, 2013):

- Today's biodiesel "cost of production" range is between $3.05 and $3.65.

o What is the cost of production of biodiesel?

- (soybean oil – about 50% of the feedstock – Sept 25, 2013)

42 cents x 7.5 lbs. of feedstock = $3.15 + .50 (operating exp.) = $3.65

- (yellow grease and other waste oils – about 50% of the feedstock – Sept. 25, 2013)

34 cents x 7.5 lbs. of feedstock = $2.55 + .50 (operating exp.) = $3.05

- Today's RIN value is $.66[1].

- With the RIN included, the potential low end price for purchased biodiesel could be lower than the terminal rack price of petroleum diesel.

- Today's "terminal rack price" of petroleum diesel fuel is $2.99.

- The rack price is what fuel distributor's pay for diesel fuel.
- The retail cost is much higher - standing at a national retail average price of $3.95.

Before a biodiesel producer sells gallons to a blender or an obligated party, the parties negotiate the value of the biodiesel, including the value of the RIN credit. On Sept. 25, 2013, the RIN value for a gallon of biodiesel was $.99 cents. It is difficult to determine the exact value of the RIN benefit to the retail consumer – but the RIN value creates downward pressure on biodiesel, which assists in creating competition with diesel fuel.

Therefore, it is easy to see the favorable economics for fuel distributors, fleet managers, and others to seek out biodiesel when the RIN value is taken into account. When they can purchase biodiesel for less and blend it into petroleum diesel, they are able to pass some of those savings along to consumers.

a. What is the impact on the cost of production if there is no tax credit?

We have historical data for both feedstocks and RIN prices. There is no correlation between the cost of production and the tax credit.

Again, there is a lot of information here.

1. Outline OMB Meeting on 9-19
2. Biodiesel GHG Reductions in Billions of Pounds
3. Bates White Response to NERA Study on the RFS
4. OMB Economic Summary of Increased Biodiesel Production
5. National Results – Economic Impacts, Jobs & Wages (Direct and Total)
6. Global Rendering Data
7. LMC Current and Future Supply of RFS2 Feedstocks
8. ABF Economics Waste Grease and Oils Study

9. Biodiesel is Saving Consumers Money at the Pump

If you have any questions, then please do not hesitate to contact us.

Thank you.

Larry Schafer

National Biodiesel Board

O: [redacted]

M: [redacted]

[redacted]

Biodiesel – America's Advanced Biofuel!

www.americasadvancedbiofuel.com

1331 Pennsylvania Ave. NW

Suite 505

Washington DC 20004

---

[1] 66 cents x a 1.5 RIN value = $.99 cent RIN value for biodiesel on Sept. 25, 2013.

Year	Gallons of Production (billions)	Billions of Pounds of GGH Reduction*	Millions of tonnes of GGH Reduction*	OMB Social Cost of Carbon million $ $38/metric ton	Passenger Vehicles Removed from Roadways (in millions)
2005	0.112	2.1	1.0	$36	0.15344
2006	0.224	4.2	1.9	$73	0.30688
2007	0.5	9.4	4.3	$162	[redacted] (b) (6)
[redacted]	0.691	13.0	5.9	$224	0.94667
2009	0.545	10.2	4.6	$177	0.74665
2010	0.315	5.9	2.7	$102	0.43155
2011	1.100	20.7	9.4	$356	[redacted] (b) (6)
[redacted]	1.100	20.7	9.4	$356	1.507
2013	1.7	32.0	14.5	$551	[redacted] (b) (6)
[redacted]	1.28	24.1	10.9	$415	1.7536
2014	2	37.6	17.1	$648	2.74
Totals:	**9.567**	**118.2**	**53.6**	$2,037	**8.61319**

^ = 1 gallon of biodiesel creates 292 rations of protein

= 1 gallon of biodesel removes the equivalent of 0.00137 passenger vehicles from U.S. roadways.
6976.7437

* = 1 gallon of biodiesel reduces GGH by 18.8 pounds Based on 76.4% reduction published by USDA/University of Idaho

Projected 2013

2013	1.7	32.0	14.5	$551	2.3

Diesel Trucks Removed from Roadways (in millions)	Rations of Protein Created (in billions)^
	32.7
	65.4
	146.0
	201.8
	159.1
	92.0
	321.2
	321.2
	496.4
	373.8
	584.0
	1835.8

2012

496.4

2969

BATES WHITE
ECONOMIC CONSULTING

Summary of Response to:

"Economic Impacts Resulting from Implementation of RFS2 Program" by NERA Economic Consulting, on behalf of the American Petroleum Institute, October 2012

David W. DeRamus, Ph.D.
Bates White Economic Consulting

Prepared for the National Biodiesel Board
September 17, 2013

In October 2012, NERA published a report concluding that the Renewable Fuel Standards (RFS2) would cause significant harm to the U.S. economy by 2015. According to NERA, the RFS2 volume mandates would be greater than the amount of feasible U.S. biofuel demand by 2013,[1] which (according to NERA) would cause the U.S. economy to enter a "death spiral,"[2] as refiners restrict the amount of refined petroleum supplies (especially diesel) to comply with a shortage of RINs, dramatically increase prices (especially for diesel), and shutter refinery capacity. According to NERA, in 2015 alone, the RFS2 will result in a $770 billion decline in U.S. GDP.

The results of the NERA study are based on four flawed assumptions. First, NERA incorrectly assumes that the EPA has no meaningful flexibility in setting the total annual biofuel volumes under RFS2 – even in the face of severe harm to the U.S. economy. Second, NERA incorrectly assumes that the approximately 10% "blend wall" imposes an insurmountable constraint on U.S. biofuel consumption after 2013, despite significant opportunities for increased penetration of E15, E85, and biodiesel, particularly in response to significant price increases or binding supply constraints. Third, NERA assumes that there would be no other significant changes in the markets for biofuels, petroleum products, or RINs in the face of these predicted dramatic price increases and supply constraints. Fourth, NERA assumes that eliminating the RFS2 requirements would have no negative impact on U.S. GDP, even though the RFS2 program has played an important role in the recent growth of the U.S. biofuels industry, and is expected to play an increasingly important role in stimulating additional investment in advanced biofuel technology and production capacity.

[1] The NERA Report adopts this result obtained in a "Phase 1" report prepared by Charles River Associates, also for the American Petroleum Institute.
[2] NERA Report, p. 2.; Figure 1, p. 3.

With regard to NERA's first flawed assumption, the EPA has significant flexibility in administering the RFS2 program (including the establishment of the RIN program) and in setting annual volume targets (RVOs and percentages) for each category of biofuels. In particular, the EPA has the authority to waive, in whole or in part, the RFS2 volumes mandated by Congress, if there is inadequate domestic supply, or if the RFS2 volumes were to "severely harm the economy."[3] Since 2010, the EPA has repeatedly exercised its waiver authority with respect to the cellulosic biofuel mandate. In fact, the EPA has demonstrated broad flexibility in how it administers the RFS2 program more generally. For example, the EPA has increased the required biodiesel volumes above the level initially mandated by Congress, in line with demonstrated market capacity to both supply and consume this increased amount of biodiesel.[4] Most recently, the EPA announced that it would extend the annual compliance period, allowing obligated parties to achieve compliance for 2013 by June 30, 2014, which allows them to better optimize their use of RIN credits in any given year (given the RIN carryover provisions established by the EPA, and given the market prices for RINs). In addition, the EPA has also explicitly stated that it will use its statutory "flexibilities" to address potential future limits in the amount of biofuels that the market can accommodate.[5]

With regard to NERA's second flawed assumption, the assumed 10% "blend wall" is by no means a "hard-and-fast" technological constraint (and thus, it is not in fact a "wall"), but rather a gray line resulting from EPA's own regulatory policies. For example, in 2010, EPA ruled that E15 was allowed to be used in model year 2007 and later light-duty vehicles (cars and light-duty trucks), and in 2011, the EPA extended the use of E15 to model year 2001 – 2006 light-duty vehicles. Thus, as the vehicle fleet ages with each passing year, and as E15 is increasingly incorporated into the U.S. fuel supply, the "blend wall" will be increasingly pushed back. Further, much of the economic harm predicted by NERA is a result of reduced *diesel* supply and increased *diesel* prices predicted by its model. Biodiesel, however, is far from being constrained by either supply or demand limitations. Biodiesel is currently well below NERA's assumed diesel "blend wall" of 5% (in the form of B5 penetration), and there is a broad consensus that the use of biodiesel is not limited to B5 (whether with respect to distribution infrastructure or engine performance). Thus, given the current excess biodiesel capacity well above the RFS2 mandates, there are significant unexploited opportunities to further increase biodiesel production and consumption, which can further help push back the "blend wall" – particularly since each additional biodiesel RIN credit is equivalent to 1.5 conventional RIN credits.

[3] 42 USC § 7545(o)(2)(7)(A)(i).
[4] The EIA recently reported that biodiesel production reached a record 89,000 bbl/d in June 2013 (nearly 1.4 billion gallons on an annual basis). See: http://www.eia.gov/forecasts/steo/report/renew_co2.cfm.
[5] See, e.g., http://thehill.com/blogs/regwatch/energyenvironment/315761-epa-calls-for-mixing-165-billion-gallons-of-biofuel-with-gas-in-2013; see also: http://www.epa.gov/otaq/fuels/renewablefuels/documents/420f13042.pdf.

With regard to NERA's third flawed assumption, NERA assumes that there would be no significant change in technology, investment, consumer demand, or trade in response to the dramatic price increases and supply constraints that its model predicts (assuming, for the sake of argument, that the EPA were to ignore its statutory obligations to grant waivers in the face of such adverse economic effects). For example, if the supply of gasoline were truly limited by the availability of RIN credits (as NERA's model predicts), one would expect the price of E85 to decline precipitously, and the demand for E85 to increase (since E85 generates substantially more RIN credits than E10); likewise, one would expect there to be a rapid increase in the roll-out of E15. With rapidly escalating RIN prices predicted by NERA's model, one would also expect additional advanced biofuel capacity to be brought on line – much of which becomes economic at prices well below those predicted by NERA – which would generate additional RIN credits faster than the use of conventional ethanol.[6] In addition, the U.S. imports significant sugarcane-based ethanol which qualifies for advanced biofuel RIN credits; if NERA's predicted price and quantity effects were to occur, one would expect a large increase in such imports, either supplementing or displacing U.S. conventional ethanol consumption (since a gallon of advanced biofuels generates more RINs than conventional ethanol). NERA's modeling approach to "holding everything else constant" in the event of the assumed price increases and supply constraints is simply unrealistically simplistic in the context of this rapidly changing industry.

With regard to NERA's fourth flawed assumption, eliminating the RFS2 volume requirements will undermine the further development of the U.S. biofuels industry, which has been an important contributor to U.S. GDP growth. The RFS2 program was designed to provide "volume certainty" to potential investors in advanced biofuels in particular; and, via tradeable markets for RINs, to provide market-based signals to incentivize that investment. To date, the EPA has carefully – and flexibly – administered the RFS2 program to accommodate capacity constraints, compliance costs, and other market realities, which has contributed to the expansion of biofuels production and the development of an increasingly liquid RIN market. Eliminating the RFS2 volume requirements would undermine investor confidence in the biofuels and RIN markets more generally, and thereby itself bring about a reduction in U.S. GDP and household incomes.

[6] Each gallon of biodiesel, cellulosic biofuels, biobutanol, or non-ester renewable diesel is equivalent to more than 1 RIN of conventional ethanol.

Impacts of Increased Use of Biomass-based Diesel Fuel

Comparative Economic Analysis

Prepared By:
National Biodiesel Board

September, 2013

BIODIESEL
America's Advanced Biofuel

Executive Summary

In 2007, the Energy Independence and Security Act (EISA) expanded the Renewable Fuel Standard (RFS) program to increase the required volumes of renewable fuel and to include diesel transportation fuel. The statute requires EPA to "ensure" "transportation fuel" sold in the United States contains "at least" the applicable volumes of renewable fuels. The applicable volumes for biomass-based diesel were set in the statute, increasing to 1 billion gallons through 2012. For years 2013 and later, the statute requires EPA to set the volume mandates for biomass-based diesel up from 1 billion gallons, based on a consideration of specific factors listed in the statute. EPA's discretion in setting the volumes, however, is required to be based on the balancing of all the considerations outlined in the statute to ensure continued increasing use of domestic, advanced biofuels, such as biomass-based diesel.

The National Biodiesel Board, working with World Agricultural Economic and Environmental Services (WAEES) and LMC International, has examined the economic impacts of two distinct alternatives; a baseline or "no-action regarding the biomass-based diesel fuel volume obligation" alternative that maintains the biomass-based diesel volume obligation at 1.28 billion gallons per year in 2014 and one alternative that increases the biomass-based diesel volume obligation to 1.7 billion gallons per year. Specifically, the analysis examines the additional cost/savings of increased biodiesel use (RIN valuation) and job creation in addition to indirect impacts such as expansion of the fuel supply and indirect economic benefits.

A partial equilibrium econometric model maintained by WAEES was utilized to quantify benefits and costs. The WAEES partial equilibrium modeling system is made up of a set of global econometric models emulating the behavior of the global agricultural and biofuels sectors. The partial equilibrium models are made up of three modules: crops, livestock, and biofuels. The U.S. ethanol and biodiesel sectors are set up as partial equilibrium models with supply and demand equations and an endogenous ethanol and biodiesel price. A complete description of the WAEES models can be reviewed on pages 6 to 11. The job creation and other economic benefits were estimated using economic impact multipliers, specifically the RIMS II Regional Economic Impact Modeling system prepared by the U.S. Bureau of Economic Analysis. RIMS multipliers are commonly used economic input-output (I-O) models used to analyze the structure of the economy and to estimate the total economic impact of projects or policies. . I-O models are constructed based on the concept that all industries within an economy are linked together; the output of one industry becomes the input of another industry until all final goods and services are produced.

The baseline scenario was designed to simulate market conditions in situation where no policy action is taken regarding the biomass-based diesel fuel volume obligation. The alternative scenario is to increase the biodiesel mandate to 1.7 billion gallons in 2014. *This is the only change in assumptions from the baseline scenario.* In the 1.7 billion scenario the increase in the advanced RIN requirement is met with a greater proportion of biodiesel. The 1.7 billion gallon mandate results in biodiesel RIN values that are slightly higher in marketing year 2013/14 and 2014/15. However advanced RIN values are slightly lower since less sugarcane based ethanol must be imported from Brazil. In addition, conventional RIN values also ease slightly. Model results, which include forecasted RIN valuation, can be reviewed on page 21.

A comparison of model results for the two scenarios begins on page 20. Costs associated with the two scenarios can be evaluated based on the RIN values associated with the biofuels that are available to meet the advanced mandate which include biodiesel and sugarcane ethanol and any impacts on conventional RIN values. The analysis concludes that the direct cost of biodiesel RINS from increasing the biomass-based diesel volume obligation in 2013/14 was $192 million. However, this cost is offset by the savings in the cost of sugarcane ethanol advanced RINS of $86 million as well as the savings in cost of convention RINs of $154 million. This suggests that the policy change to 1.7 billion gallons of biodiesel has a cost savings of $48 million in 2013/14 (Oct 2013 to Sep 2014).

Additional direct benefits from increasing the 2014 volume obligation for biomass-based diesel fuel will be provided by the economic activity associated with producing the additional fuel. Specifically, increasing the volume obligation will support almost 1,900 direct jobs in the economy. These jobs will be associated with both the production of the additional 420 million gallons of biomass-based diesel fuel as well as the fats and oils required as feedstock, and transporting both feedstock and finished diesel fuel. In addition to direct employment benefits and a cost savings for U.S. consumers, increasing the 2014 volume obligation for biomass-based diesel fuel also has additional direct benefits. Producing 1.7 billion gallons of biodiesel in 2014 is expected to generate an additional $2 billion of GDP and $96 million of household income. Direct benefits and costs are summarized in the table below and documented in the full report. Indirect and ancillary benefits, in addition to direct benefits, are summarized in table form on page 33 of this report.

Economic Impacts (Benefits) Associated with Increasing the Biomass-based Diesel Volume Obligation to 1.7 Billion Gallons in 2014.

Annual Direct Economic Impacts		
Changes in RIN Program Compliance Costs		*mil dollars*
Net Estimated Impact (Savings) for Oct 2013 to Sep 2014		**$48**
Annual Direct Economic Im		
Jobs	1,890	
Increased Wages (Mil $)		**$96.1**
Increased GDP (Mil $)		**$2,009.0**

** Additional economic benefits from increasing biodiesel production by 420 million gallons*

Statement of Need

In 2007, the Energy Independence and Security Act (EISA) expanded the Renewable Fuel Standard (RFS) program to increase the required volumes of renewable fuel and to include diesel transportation fuel. In establishing and expanding the RFS, Congress sought to promote U.S. biofuel production, diversify feedstocks and increase use of advanced biofuels "to enhance the energy security of the United States." S. Rep. No. 110-65 at 1 (2007); *see also NPRA v. EPA*, 630 F.3d 145, 156 (D.C. Cir. 2010). Congress recognized, "[a]s the nation's reliance on foreign supplies of petroleum has grown, so too has the need for federal policies that promote new technologies and more efficient use of energy, tap the potential for home-grown biofuels, and nurture America's talent for innovation. Such policies reinforce the security objectives of the United States, are consistent with principles of environmental stewardship, and hold the promise of new job-creation and enhanced competitiveness in an increasingly global economy." S. Rep. No. 110-65 at 2. "While not as large of a market as gasoline, petrodiesel is enormously significant to our economy, and reducing our reliance on foreign feedstocks for this diesel is of equal importance in our efforts to increase energy security." 152 Cong. Rec. S6285-01, S6288 (June 21, 2006) (Senator Obama). In EISA, then, Congress established a specific mandate for biomass-based diesel, requiring increasing amounts of renewable fuel be used in the diesel fuel pool. 42 U.S.C. § 7545(o)(1)(L), (o)(2)(B)(i)(IV); 74 Fed. Reg. 24,904, 24,913 (May 26, 2009).

The statute requires EPA to "ensure" "transportation fuel" sold in the United States contains "at least" the applicable volumes of renewable fuels. 42 U.S.C. § 7545(o)(2)(A)(i). The applicable volumes for biomass-based diesel were set in the statute increasing to 1 billion gallons through 2012. *Id.* § 7545(o)(2)(B)(i)(IV). For years 2013 and later, the statute requires EPA to set the volume mandates for biomass-based diesel up from 1 billion gallons, based on a consideration of specific factors listed in the statute. *Id.* § 7545(o)(2)(B)(ii), (v). This established the RFS for the diesel pool; "The statute requires EPA to ensure that these "minimum" volumes are met, and Congress intended that use of renewable fuels continue to increase over time. The biomass-based diesel program further ensures that the advanced biofuel mandates are met. Increasing the biomass-based diesel requirement would make "it more likely that we will not need to modify the advanced biofuel mandate in 2013 and, therefore, that the Congressional goal for advanced biofuel use in 2013 can either be satisfied, or at least come closer to satisfaction." 76 Fed. Reg. 38,844, 38,874 (July 1, 2011).

As it did with the RFS1, the statute set minimum volume requirements through 2012 for biomass-based diesel, and, "[t]hereafter the requirements may be increased based on the nation's production and use of these fuels, as well as consideration of our economy and environment." 151 Cong. Rec. S2998-01, S2999 (Mar. 17, 2005) (Sen. Lugar - S. 650). "[T]his increased production and use will spur investment in critical infrastructure that will allow for the economical use of renewable fuels by all Americans." *Id.* Allowing EPA to increase volumes "will ensure that market demand for these fuels grows accordingly." 151 Cong. Rec. S2998-01, S3003 (Mar. 17, 2005) (Sen. Harkin - S. 650). The purpose of the mandate, and a goal of Executive Order 13563, is to "'promote predictability and reduce uncertainty.'" 77 Fed. Reg. 1320, 1325 (Jan. 9, 2012). A statutory mandate, by definition, is intended to influence market behavior and inherently includes increased costs. In expanding the RFS, Congress understood there may be some costs, "though these costs may be offset in whole or in part by reducing energy consumption and our dependence on foreign oil." S. Rep. No. 110-65 at 18. In light of the simple economics behind a mandate, Congress included some cost considerations among the factors so that the volumes would not be increased with no constraints on whether those increases were reasonable. EPA's discretion in setting the volumes, however, is required to be based on the balancing of all the considerations outlined in the statute to ensure continued increasing use of domestic, advanced biofuels, such as biomass-based diesel.

Included in those key criteria are several compelling public policy benefits associated with the enhanced production and use of biodiesel in the U.S.

Biodiesel Can Replace Imported Ultra-Low Sulfur Diesel (ULSD) Fuel and Reduces our Dependence on Foreign Oil. Biodiesel can play a major role in expanding domestic refining capacity and reducing our reliance on foreign oil. In addition, biodiesel is an extremely efficient fuel that creates 5.5 units of energy for every unit of fuel that is required to produce the fuel.

Biodiesel is Good for the Environment: Biodiesel is an environmentally safe fuel, and is the most viable transportation fuel when measuring its carbon footprint, life cycle and energy balance. The lifecycle analysis conducted by EPA found that biodiesel reduces GHG emissions by as much as 86 percent when compared to petroleum diesel fuel.

Biodiesel's emissions significantly outperform petroleum-based diesel. Research conducted in the U.S. shows biodiesel emissions have decreased levels of all target polycyclic aromatic hydrocarbons (PAH) and nitrited PAH compounds, as compared to petroleum diesel exhaust. Research also documents the fact that the ozone forming potential of the hydrocarbon emissions of pure biodiesel is nearly 50 percent less than that of petroleum fuel. Biodiesel production also has been found to produce less smog forming emissions than petroleum diesel production. *Id.* at 81. Pure biodiesel typically does not contain sulfur and, therefore, reduces sulfur dioxide exhaust from diesel engines to virtually zero.

The Biodiesel Industry is Creating Green Jobs and Making a Positive Contribution to the Economy: In 2012, the biodiesel industry was a bright spot in the RFS – exceeding the 2012 one billion gallon requirement by producing roughly 1.05 billion gallons of fuel. That translated directly into almost 47,000 jobs, generating $1.95 billion in household income and $9.74 billion in GDP.

Increasing the 2014 RFS requirement from 1.28 to 1.7 billion gallons represents modest, sustainable growth and will support more than 7,300 additional jobs across the country. In fact, according to a recent economic study, production of 1.7 billion gallons of biodiesel would support 59,305 jobs nationwide, along with almost $2.5 billion in household income and $16.8 billion in GDP.[1]

Sufficient biodiesel production capacity exists based upon firms registered with U.S. EPA for the RFS2 Program. In addition, the U.S. biodiesel industry demonstrated in 2013 the ability to produce sufficient quantities to meet and exceed the 2013 Biomass-based Diesel fuel mandated volumes of 1.28 billion gallons.

With demonstrated public benefits, the purpose of this analysis is to quantify the benefits that accrue to U.S. consumers and any associated costs of increasing the Biomass-based Diesel Fuel requirement from 1.28 billion gallons to 1.7 billion gallons in 2014.

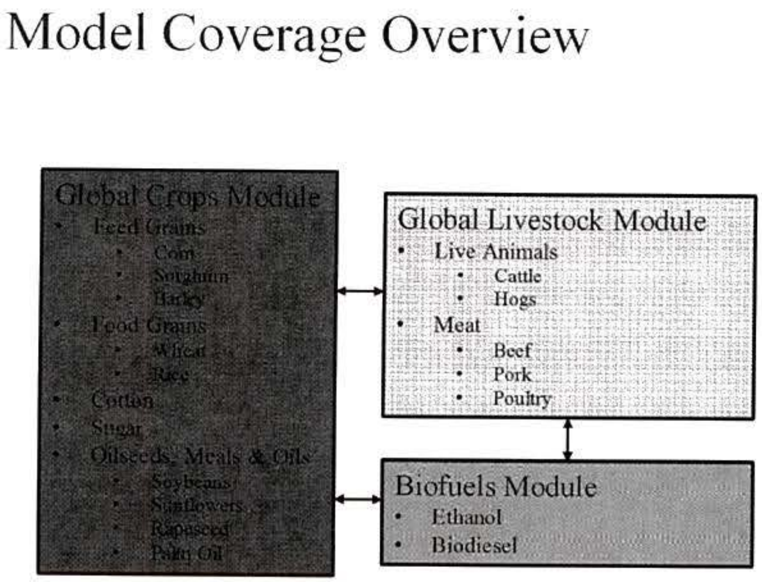
Comparative Analysis

[1] LMC International. "The Impact of the U.S. Biodiesel Sector on the U.S. Economy". September, 2013. Report prepared for the National Biodiesel Board.

This analysis will examine the benefits and costs associated with increasing the Biomass-based Diesel 2014 volume obligation from 1.28 billion gallons to 1.7 billion gallons. Specifically, the analysis examines the additional cost/savings of increased biodiesel use (RIN valuation) and job creation in addition to indirect impacts such as expansion of the fuel supply and economic development benefits. Although obligated parties are the specific group of companies that must comply with the RFS, the scope of this BCA is U.S. consumers as a whole. This analysis will examine the impacts of increased biodiesel use on the value of RINs in the U.S. The analysis will specifically examine; impacts on the price of diesel fuel, biodiesel, and ethanol, energy security benefits, health benefits, and increased economic activity due to the support of additional jobs in the U.S. economy. To quantify benefits and costs, a partial equilibrium econometric model maintained by World Agricultural Economic and Environmental Services (WAEES) was utilized.

Overview of the WAEES Modeling System

The WAEES partial equilibrium modeling system is made up of a set of global econometric models emulating the behavior of the global agricultural sector. The partial equilibrium models can be broken down into crops, livestock and biofuels components encompassing feed grains, food grains, cotton, sugar, oilseeds, ethanol, biodiesel, beef, pork, and poultry.



The WAEES models cover 38 countries/regions with an additional 12 regional aggregates including the world total. WAEES follows USDA's reported data coverage which may mean that a zero is reported for a particular commodity which USDA does not cover or has discontinued covering. USDA currently covers at least 90 percent of global production; therefore, the countries which are omitted represent a small portion of total global production. Specifically the WAEES model includes Canada, Mexico, the United States, Caribbean and Central America, Argentina, Brazil, Other South America, the European Union 27, Other Europe, Russia, Ukraine, Uzbekistan, Other Former Soviet Union, Saudi Arabia, Turkey, Other Middle East, China, Japan, South Korea, Taiwan, Other East Asia, India, Pakistan, Other South Asia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, Vietnam, Other Southeast Asia, Australia, Other Oceania, Egypt, Other North Africa, Kenya, South Africa, and Other Sub-Saharan Africa.

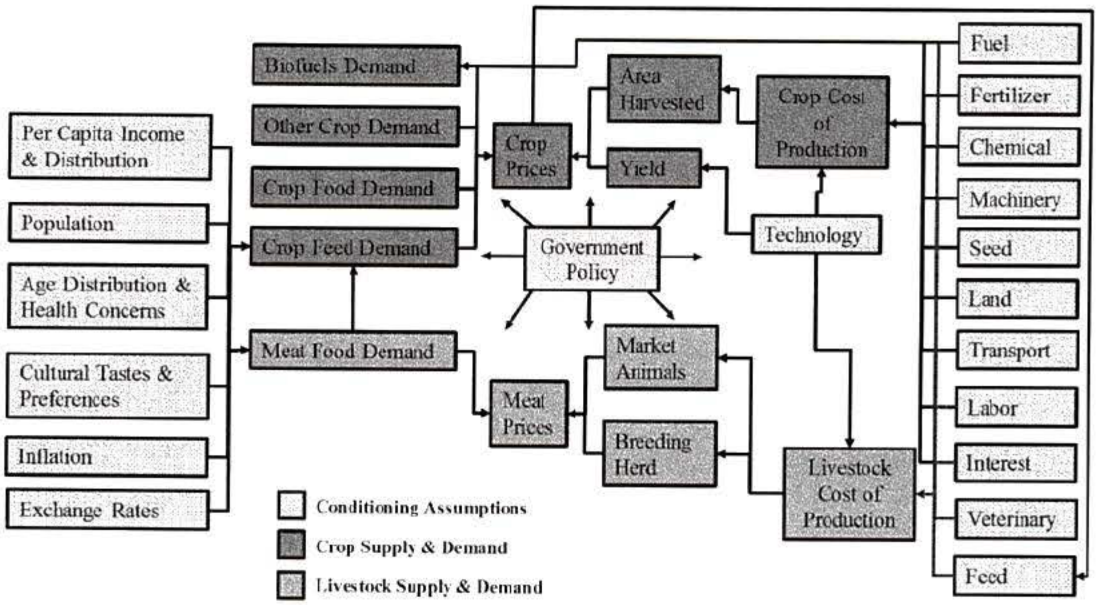
Partial Equilibrium Models

Each partial equilibrium module is broken down into commodities with a system of structural equations capturing the supply and demand components for each of them. The drivers of these equations are theoretically derived based upon the behavioral postulates from economic theory of profit maximization by the market participants and utility maximization by consumers subject to various domestic and international trade policies. The diagram below illustrates the inter-linkages of the crops and livestock model. In the diagram, the blue boxes represent the key drivers (conditioning assumptions) of the agricultural sector including income, population, culture, inflation, exchange rates, domestic and trade policy, technology and input costs. The green boxes are an aggregate approximation of the crops sector. As relevant, each box represents an equation for each commodity covered. For example, there are specific feed demand equations for corn, sorghum, barley, soybean meal, sunflower meal, etc. The pink boxes are an aggregate approximation (within the diagram) of the detailed livestock sector model encompassing beef, pork and broilers. The diagram illustrates how income, population, and other factors drive food demand for crops and meats. Crude oil prices (and policies) drive the demands for biofuels. As demand increases, crop prices increase providing an incentive for production expansion. Technology growth drives yield expansion providing much of the needed production. Crop area may also grow to meet demand needs although in developed countries this often amounts to tradeoffs among crops. Ultimately supply and demand are balanced via commodity prices. If demand is stronger than supply, commodity prices increase until demand growth is slowed and supply growth is increases enough for supply and demand to balance.

Global Geographic and Commodity Coverage

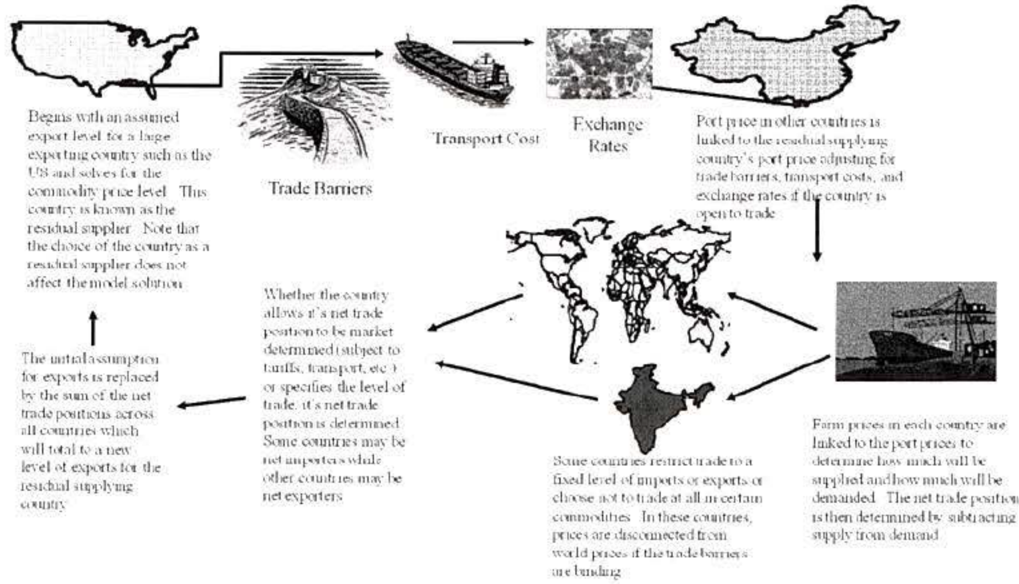
Partial Equilibrium Modeling System

(Conceptual Framework Representation for One Country)



Partial equilibrium models solve iteratively to find equilibrium by balancing global supply and demand. This occurs at the individual country level for each commodity. Most countries are at least somewhat open to trade albeit with tariffs. The trade diagram below illustrates conceptually how global supply and demands are balanced within a "global" price equilibrium solution. Typically a large exporting country is chosen as the residual supplier for the world. The choice of this country does not affect the solution. The commodity price in the residual supplying country is solved for by assuming an initial level of exports. This price is then transferred to other countries through trade barriers, transportation costs, and exchange rates. Based on a given price level, each country determines how much it is willing to supply or demand at that price and subsequent how it wants to import or export. Occasionally a country has tariffs high enough that no trade will occur or only a fixed amount of trade will occur at the lower tariff level. Note that in those countries internal prices may not reflect the world level of prices because supply and demand must be balanced from domestic sources. After the supply and demand in each country is determined and the implied trade position, these trade positions are summed to find the new level of exports for the residual supplying country replacing the initial assumption. The process then repeats itself until prices adjust to balance global supply and demand. For example, if the sum of trade across all other countries is lower than the initial starting assumption for the residual supplying country, the price level in the residual supplying country will fall to balance supply and demand. This lower price level will then get transferred to all other countries affecting their supply and demand and ultimately net trade positions and of course replace the exports again in the residual supplying country. This process continues until global supply and demand balance.

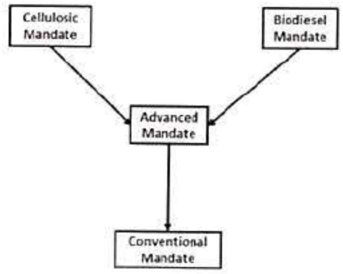
How do partial equilibrium models solve for a global supply and equilibrium price?



An Example of the US Partial Equilibrium Model for the Biofuels Sector

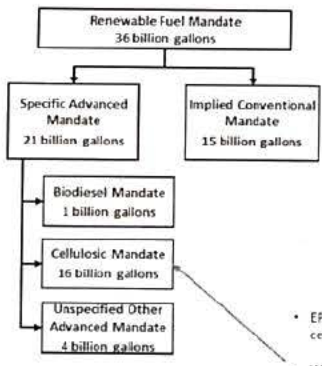
Within the WAEES model, the US ethanol and biodiesel sectors are set up as partial equilibrium models with supply and demand equations and an endogenous ethanol and biodiesel price. The structure of the model has its roots in the ethanol specifications documented by John Kruse, Patrick Westhoff, Seth Meyer, and Wyatt Thompson in a 2007 journal article in AgBioForum entitled, "Economic impacts of not extending biofuel subsidies." With the second Renewable Fuel Standard, these original specifications have been updated to reflect the hierarchical system of mandates. The biofuels mandates require compliance with each specific mandate type including biodiesel, cellulosic, advanced and the overall renewable fuel mandate. The rational for different mandates in the legislation was to encourage biofuel producers to move towards feed stocks that provided the greatest level of greenhouse gas (GHG) reductions compared with conventional petroleum. The term "advanced biofuels" was used to describe biofuels that reduced GHG emissions by at least 50 percent compared with a 20 percent reduction requirement for conventional feed stocks. Cellulosic derived biofuels must reduce GHG emissions by 60 percent. Compliance with the mandates by the obligated parties is enforced by the EPA through as system of Renewal Identification Numbers (RINS) assigned to each type of biofuel produced. Obligated parties must demonstrated that they have met their assigned obligations through the number of RINS they have for each type of fuel. Theoretically there could be a specific RIN value for each type of mandate – cellulosic, biodiesel, advanced, and conventional, if each mandate was binding. Mandates are binding when the market is forced by policy to produce more than what normal economic conditions would suggest. The advanced biofuels are typically more expensive to produce than conventional biofuels resulting in those mandates being more binding than conventional biofuels mandates. Therefore RIN values (or prices) are typically significantly higher for advanced biofuels than conventional biofuels.

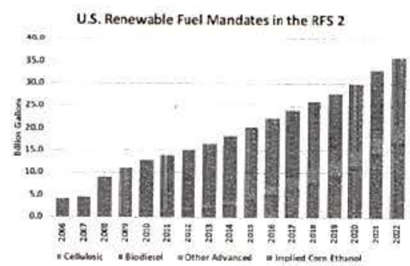
Hierarchical RINS Modeling



- Theoretically there can be 4 different RIN prices specific to each mandate if all the mandates are binding.
- Mandates are binding when the market is forced by policy to produce more than what normal economic conditions would suggest.
- Given the hierarchy of the mandates, it must be the case that RIN values for biodiesel are greater than or equal to advanced RIN values and advanced RIN values must be greater than or equal to conventional RINS. This is because biodiesel RINS can be used as advanced RINS and advanced RINS can be used as conventional RINS. (This process is referred to as demotion.)
- Biodiesel RINS can have the same value as advanced RINS if the biodiesel mandate is less binding than the advanced mandate.

US Biofuels Mandates in 2022

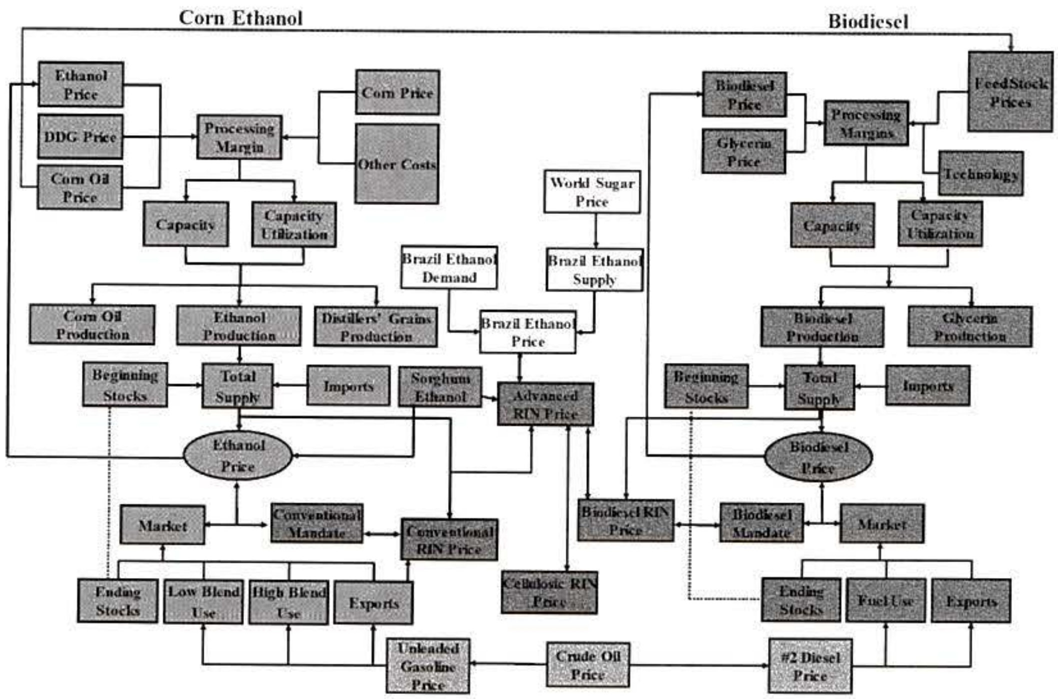




- EPA has waived the cellulosic mandate in 2011 and 2012 because cellulosic biofuels are still very expensive to produce.
- While the cellulosic mandates has been waived, the overall advanced mandate continues to be retained forcing more demand for other advanced fuel feed stocks such as biodiesel and sugarcane ethanol.

A detailed diagram of the U.S. biofuels models is presented below. The demand for biofuels is largely mandate driven. However, if crude oil price edge higher it is possible for ethanol demand to be driven by market forces although the blend wall presents another hurtle. The supply of biofuels is driven by the profit margins of the biofuel plants. Profit margins are derived by subtracting the cost of the feedstocks and other variable costs of production from the valued of the products. In the case of ethanol, the value of the ethanol plus the value of the byproducts including corn oil and distiller's grains form the gross returns. The cost of ethanol is composed of the feed stock cost, primarily corn, and the other inputs. In the case of biodiesel, the value of biodiesel and the byproduct glycerin form the gross returns. The cost of producing biodiesel is composed of the feed stock costs such as vegetable oils, waste oils, corn oil and other inputs. The respective margins for ethanol and biodiesel drive capacity expansion in the longer term and capacity utilization in the short term for each sector. Equilibrium between biodiesel supply and demand is found by solving for the biodiesel price.

US Biofuels Partial Equilibrium Models



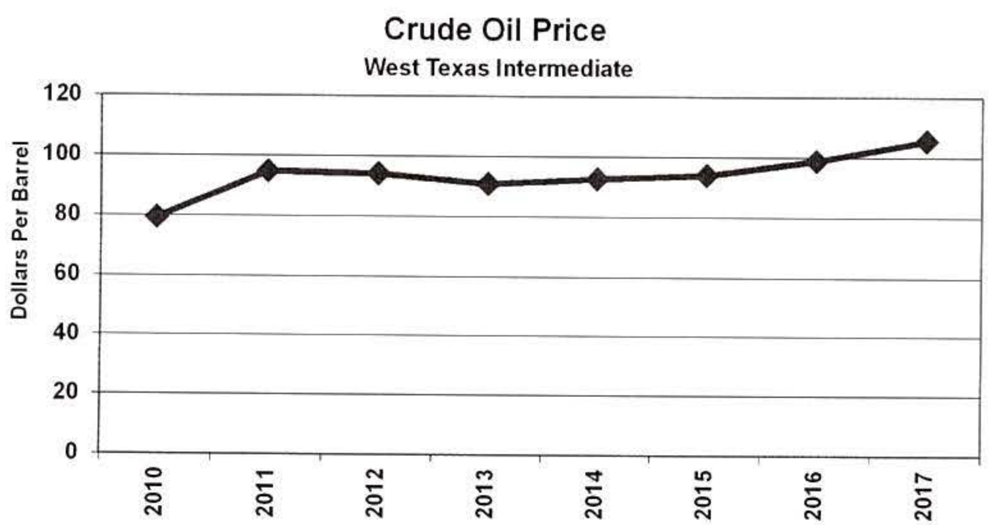
Scenario Assumptions

The following paragraphs described the assumptions used in formation of the two scenarios used in this analysis. Since a policy change is imminent based on statements from EPA, the baseline scenario is designed to be a realistic scenario of the many possible futures for biofuels policies. The second scenario is designed to demonstrate the effects of increasing the biodiesel mandate from 1.28 billion gallons in 2013 to 1.7 billion gallons in 2014. As described below, while the growth in the advanced mandate is assumed to be reduced from legislated levels, some increase is still expected. The only significant fuel sources meeting the advanced fuel criteria are U.S. biodiesel or imported Brazilian sugarcane ethanol.

The following assumptions were utilized for the baseline and the baseline + 1.7 billion gallon biodiesel scenario:

Crude Oil Price Assumptions

The crude oil price projections used in this analysis are from the U.S. Department of Energy's Energy Information Administration (EIA) as part of their early estimates release on December 5, 2012, for the 2013 Annual Energy Outlook. The crude oil price selected is the "Reference Case" Scenario.

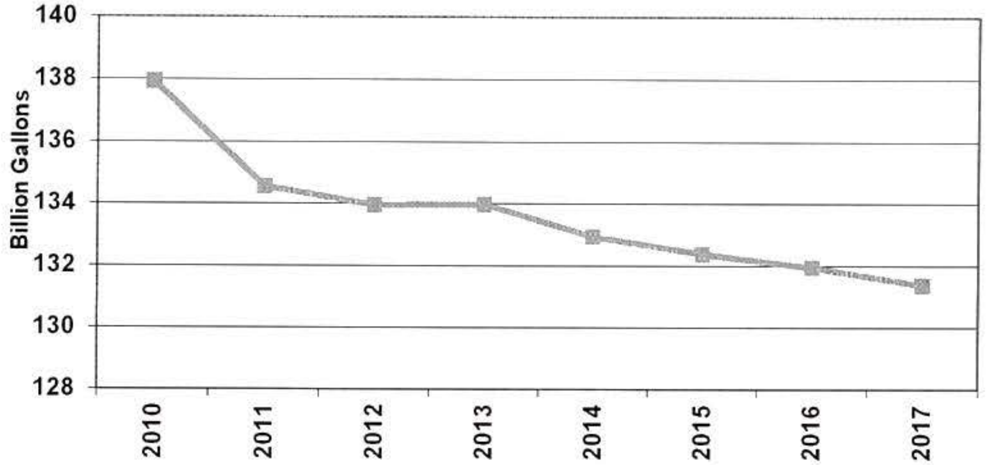


Source: US Dept. of Energy, Energy Information Administration, Reference Case - Dec 5, 2012

Motor Gasoline Use

Similarly to crude oil prices assumptions, this analysis utilizes EIA's projections of motor gasoline usage. EIA projects that through fuel economy improves and other factors that U.S. motor gasoline usage will decline significantly over the next decade. The decline in motor gasoline use is especially relevant in the current market situation which is already struggling with the 10 percent ethanol blend wall. This 10 percent ethanol blend wall is about 13.4 billion gallons. Expanding ethanol consumption beyond the blend wall requires consumers to have flex fuel vehicles capable of burning higher blends as well distribution infrastructure support these blends. With motor gasoline use declining, the 10 percent blend wall gets smaller through time.

Motor Gasoline Use



Source: US Dept. of Energy, Energy Information Administration, Reference Case - Dec 5, 2012

U.S. Policy Assumptions

Formulating the correct policy assumptions for biofuels is especially difficult in this time period. The following discussion attempts to provide some background as to why the particular policy assumptions were chosen for this analysis. Certainly the future biofuels policies applied may be different from what is suggested here, but the crux of this analysis is focused on the implications of the biodiesel mandate for overall costs.

Amid the turmoil of RINs speculation, the blend wall, the failure of high blend ethanol distribution infrastructure to develop, and the absence of economically viable cellulosic biofuels, the Environmental Protection Agency (EPA) must continue to lay out a path for biofuels mandates. Over the past four years, the EPA has reduced the relatively small cellulosic mandates legislated in the 2007 Energy Independence and Security Act (EISA) by over 90 percent and even then actual cellulosic production has fallen well short of these lower levels. Yet even with the reductions in cellulosic mandates, the EPA has retained the overall EISA legislated level of the advanced mandate. Without cellulosic biofuels, there are essentially two renewable fuels with enough production volume that meet the greenhouse gas reduction criteria of an advanced biofuel. These fuels are sugarcane ethanol and biodiesel.

One of the primary factors affecting this analysis was the assumption regarding the so-called "ethanol blend wall". The ethanol blend wall issue arises because not all vehicles can fueled with higher ethanol blends. While there is some debate as to exactly where engine damage may occur, 10% blends are held to be safe for all vehicles, 15% blends may be safe for vehicles under 10 years of age, and higher blends require a flex fuel vehicle. Fuel pumps must be labeled for 15% blends, but even with labeling there has been some resistance to installing these pumps for fear of the liability associated with misfueling. The distribution infrastructure for higher ethanol blends has generally not developed in high market demand areas and the pricing of these blends must decline in order for them to compete with gasoline. While there is some consumption of higher ethanol blends, particularly E85, it still remains below 200 million gallons. The effective blend wall is then roughly 10% of total motor gasoline use (134 billion gallons) which translates in to a blend wall of 13.4 billion gallons or approximately 13.6 billion gallons if E85 is included. In 2013, the implied ethanol mandate was 13.8 billion gallons and in 2014 the legislated mandate rises to 14.4 billion gallons.

However, now that the ethanol blend wall has been reached, imports of sugarcane ethanol only add to the blend wall problem. Since the 2007 EISA legislation, it has always been clear that at some point higher ethanol blends would be required within the market place. The two major obstacles continue to be installation of the distribution infrastructure in high population areas and pricing of ethanol so that it is attractive to consumers as a substitute for gasoline. As the table below illustrates, the number of E85 service states continues to remain extremely low in east and west coast states where fuel demand is the highest and expansion of fuel distribution facilities has been very slow. The relatively small number of service stations suggests that the blend wall problem will not be correctable in the very short term even with low ethanol pricing. Consumers on the east and west coast simply wouldn't have access to the product.

Number of E85 Service Stations

State	Sep 2009	May 2013		Sep 2009	May 2013		Sep 2009	May 2013
Minnesota	351	363	Florida	26	53	Massachusetts	2	8
Illinois	192	224	Tennessee	29	44	Oregon	8	7
Iowa	123	183	Kentucky	14	35	New Jersey	0	5
Indiana	112	158	Kansas	33	32	Louisiana	4	4
Michigan	91	142	Arizona	26	32	Utah	4	4
Wisconsin	121	125	Pennsylvania	26	32	West Virgina	3	4
Missouri	95	107	Arkansas	8	30	DC	3	3
S. Dakota	80	100	N. Carolina	17	29	Montana	1	3
Ohio	63	87	Alabama	11	27	Hawaii	0	3
Colorado	76	86	Oklahoma	11	27	Connecticut	4	1
S. Carolina	85	81	Maryland	14	22	Mississippi	4	1
Texas	40	81	Virginia	8	21	Delaware	1	1
California	40	80	Washington	15	20	Maine	0	1
New York	35	80	Nevada	14	19	Vermont	0	1
N. Dakota	31	79	New Mexico	11	13	Alaska	0	0
Nebraska	48	74	Wyoming	6	9	New Hampshire	0	0
Georgia	37	60	Idaho	5	9	Rhode Island	0	0
US Total	1928	2610						

Source: U.S. Deparment of Enegy, Alternative Fuels Data Center
http://www.afdc.energy.gov/fuels/stations_counts.html

With this brief background on the forces affecting biofuels policy, the assumptions presented in the table below (entitled "U.S. Biofuel Mandate Mandates") were used as the basis for this analysis. For comparison, the table first presents the RFS2 mandates as legislated in EISA, followed by the assumptions used in the baseline for this analysis, and the assumptions used for the alternative scenario considering a higher biodiesel mandate. As per the discussion above, the cellulosic mandate has been reduced to very low levels given the past pattern of EPA's announcements. In addition, beginning in 2014, a reduction in the advanced mandate is assumed since the cellulosic portion of the advanced mandate was originally expected to grow rapidly during this period. This reduction is 205 million gallons in 2014 followed by 1407 million gallons in 2015. No change is made in the 1.28 billion gallon biodiesel mandate under the baseline.

As presented in the table, the total biofuels mandate less the advanced mandate is equal to the *implied* ethanol mandate which is traditionally how market players have thought of this category. But technically this could be any biofuel, not just starch based ethanol. It was assumed that this would be ethanol because it is the least expensive source of biofuels. However, with the blend wall limiting how much ethanol can be used, other biofuels can be used to fill that portion of the mandate. In 2013 we are beginning to see some biodiesel used to meet this portion of the overall mandate. In addition, obligated parties are drawing down their carryover ethanol RIN stocks from 2012 to comply with the implied ethanol mandate in 2013. However, the available pool of carryover ethanol RINs will be substantially lower for 2014. The messaging from EPA in August 2013 suggests that EPA anticipates the need to adjust the targets for 2014. Appreciating that the blend wall issue is not likely to be solved in the coming months and given EPA's comments, this analysis assumes that the "implied ethanol mandate" will be reduced from the legislated level of 14.4 billion gallons in 2014 to 13 billion gallons and that it will be held at 13 billion gallons in 2015 versus the 15 billion gallons legislated. This in effect allows an additional two years for infrastructure to develop and ethanol market prices to adjust and make the blend wall significantly less binding[2].

US Biofuel Mandate Assumptions

Calendar Year	2011	2012	2013	2014	2015
million gallons					
RFS 2 As Legislated					
Total Biofuels Mandate	13,950	15,200	16,550	18,150	20,500
Advanced biofuels	1,350	2,000	2,750	3,750	5,500
Cellulosic biofuel	250	500	1,000	1,750	3,000
Biodiesel	800	1,000	1,280	1,280	1,280
Implied Ethanol Mandate	12,600	13,200	13,800	14,400	15,000
Scenario 1: Baseline					
Total Biofuels Mandate	13,950	15,200	16,550	16,545	17,093
Advanced biofuels	1,350	2,000	2,750	3,545	4,093
Cellulosic biofuel	7	9	14	30	95
Biodiesel	800	1,000	1,280	1,280	1,280
Implied Ethanol Mandate	12,600	13,200	13,800	13,000	13,000
Scenario 2: 1.7 Billion Gallon Mandate					
Total Biofuels Mandate	13,950	15,200	16,550	16,545	17,093
Advanced biofuels	1,350	2,000	2,750	3,545	4,093
Cellulosic biofuel	7	9	14	30	95
Biodiesel	800	1,000	1,280	1,700	1,700
Implied Ethanol Mandate	12,600	13,200	13,800	13,000	13,000

As the table suggests the only difference between Scenario 1 and Scenario 2 is that the biodiesel mandate has been increased in scenario 2. This contrast is the primary purpose of this analysis.

Finally, another important assumption is that the biodiesel blenders' credit of $1 per gallon was not extended beyond its expiration date at the end of 2013.

<u>Global Economic Growth Assumptions</u>
WAEES used the International Monetary Fund's (IMF) October 2012 macroeconomic outlook for income growth and inflation for all countries with the exception of the United States, China, and India which are based on WAEES' slightly more conservative forecasts. Overall, real global economic growth is expected to recover to 2.89 percent in 2013, followed by 3.26 percent in 2014, and 3.44 percent in 2015. Global projections continue to show stronger income growth in developing countries especially Asia versus developed regions including the European Union and the United States. The growth rate of incomes in the developing countries is especially important for agriculture because food consumption, particularly meat and vegetable oil consumption, is very responsive to income growth. In high population regions

[2] If the "implied ethanol mandate" was not reduced, the blend wall would likely result in biodiesel filling the difference between the blend wlall plus ethanol RIN retirement and implied ethanol mandate.

such as China and India, even small changes in food demand result in large change in overall global food demands. Accounting for these demands is especially important in determining the costs and benefits of biofuels which interact with these demands.

Global inflation is projected to average 4.3 percent per year over the 2012 to 2015 period, with US inflation growing at a modest 1.9 to 2.1 percent. Population projections were taken from the United Nations and show and expected growth in world population of 1.1 percent per year over the 2012 to 2015 period.

Exchange rates are based on WAEES' global exchange rate model which utilized IMF's macroeconomic projections as key drivers for the forecast. Perhaps most important for this analysis are the projections for Brazil's exchange rates which affect the pricing of sugarcane ethanol. The exchange rate for Brazil in 2013 is projected to be 2.036 reals per U.S. dollar, followed by 2.07 reals per U.S. dollar in 2014, and 2.11 reals per U.S. dollar in 2015.

<u>Fats & Oils Supplies</u>

Although there are many new potential feedstocks for biodiesel production, the focus of this analysis remains on the fats and vegetable oils sources that are commercially available and have been utilized in the production of biodiesel historically. Examples include animal fats and yellow greases, soybean oil, canola oil, distillers corn oil recovered from dry grind ethanol plants, and camelina oil. Palm oil and its derivatives are not considered as potential feedstocks for U.S. biodiesel given EPA's proposed rule that that they do not meet the thresholds for GHG reductions. All of the feedstock options considered in this economic analysis are RFS2 approved pathways.

Although not part of this analysis, other new feedstock sources could prove to be equally important to future biodiesel growth. The current market has sent numerous price signals to invest in new technologies and methods to increase raw material supplies. Investment in new, non-edible raw materials sources such as algae, field pennycress, jatropha, mustard, and halophytes continues at an aggressive rate.

<u>Yield Technology</u>

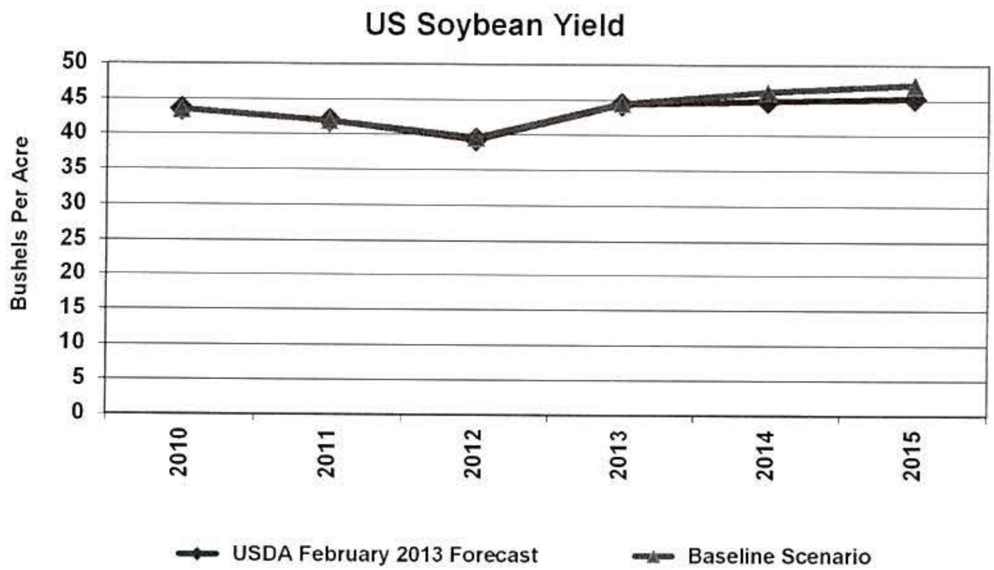
Without a doubt, the drought of 2012 significantly reduced US corn and soybean yields and sent commodity prices significantly higher. Yet even as the 2013 crop is about to be harvested, it is apparent how quickly high prices can become low prices. Yields continue to be one of the largest sources of uncertainty in making any agricultural projections. All of the technology companies continue to indicate that new genetics significantly boosting crop yields are already in the pipeline and that over the next five years significant growth in yields will occur.

Many studies including USDA's annual forecast use linear trends to project future crop yield growth. Technology companies such as Monsanto, Dupont, and Syngenta have argued that genetic engineering offers the opportunity to accelerate crop yields beyond trend levels. Recent measured yield performance backs up those claims. In 2010, Monsanto yield data from over 30,000 field comparisons across the US showed an average yield advantage of 3.8 bushels per acre for Roundup Ready 2™ versus their initial Roundup Ready 2™ with an average yield of 54 bushels per acre. Average US soybean yields in 2010 were 43.5 bushels per acre. Other research from Farmer's Independent Research of Seed Technologies suggests a yield advantage of 4.5 bushels per acre for Roundup Ready 2™ versus initial Roundup Ready™ varieties. Of the 77.4 million acres planted in 2010 only about 6 million acres were planted to Roundup Ready 2™ soybeans (7.7 percent). In 2011, the number of soybean acres planted to

Roundup Ready 2™ soybeans reached the mid-teens of millions of acres. Other soybean yield technologies in the pipeline with greater than 50 percent probability of being released include high yield traits offering 7 percent yield improvement, other herbicide tolerant soybeans, second generation insect protection, soybean fungal resistance, and aphid resistance.

Based on the demonstrated performance of technologies already available in 2010 we have assumed a 10 percent step in soybean yields above trend yield growth levels used by USDA and others. This 10 percent step is based on taking 10 percent of the average yield over the 2009 through 2011 period and incrementally phasing this in over the 2013 thorough 2019 period. This amounts to adding 0.9 bushel per acre above trend yields in 2013, 1.7 bushels per acre above trend yields in 2014, and 2.2 bushels per acre above trend yields in 2015. However, 2013 yields were reduced below trend levels to reflect poor subsoil moisture conditions from the 2012 drought resulting in soybean yields consistent with USDA in 2013 (see graph below). Soybean yield assumptions only assume technology advancements that are now commercially available and increasingly adopted by U.S. producers.

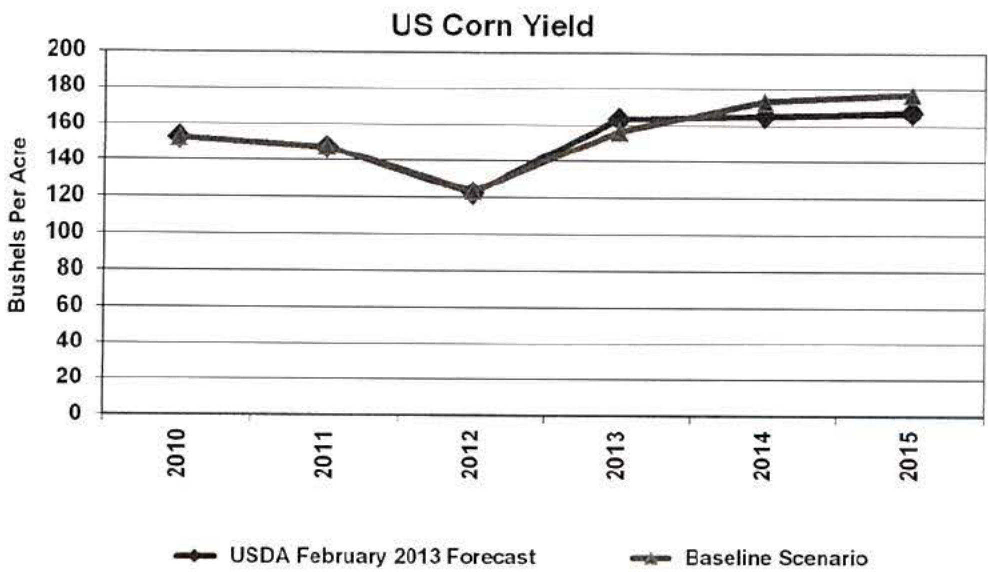
Since yield technologies tend to disseminate quickly to Brazil and Argentina, we further assume that the 10 percent step in yields extends to these countries in the planting season following the US but with a one year lag in the adoption rate.



In the case of corn, yield growth is also expected to exceed trend growth levels. Two technologies are driving this accelerated growth. The first is stacking multiple traits to enable the corn plant more resistance to various types of insect pressure in addition to herbicide tolerance. In addition, yield gains have been experienced by building the required refuge into the seed mix with a bag of seed instead of planting specific acres to corn without insect resistant traits. In 2010, Monsanto's VT Triple Pro™ corn hybrids demonstrated an 8.8 bushel per acre yield advantage over competitors based on data from 9,900 strip trials. Monsanto also notes regional difference in yield improvements from refuge reduction. In the Corn Belt, yield improvements ranged from 1.5 to 3 bushels per acre while in the southern states, yield improvements ranges from 3 to 6 bushels per acre from refuge reduction. In its final stage of development, drought tolerant corn is also emerging. This technology is more difficult to quantify in its impact because it affects the distribution of possible corn yields given precipitation variation. In the 2012 drought, there is general agreement that current genetics sustained corn yields much better than the 1988 drought which was of similar magnitude[3]. Other corn yield technologies in the pipeline with greater than 50 percent probability of being released include second generation drought tolerance, better nitrogen utilization, high yield traits, roundup ready 2 corn, generation 3 corn rootworm and corn borer traits, and other herbicide tolerant corn.

Based on the demonstrated performance of technologies already available in 2010 this analysis assumes a 7.5 percent step in corn yields above trend yield growth levels used by USDA and others. While this may seem smaller than soybeans, corn is already starting from a very high yield level (U.S. corn yields were 152.8 bushels per acre in 2010). This 7.5 percent step is based on taking 7.5 percent of the average yield over the 2009 through 2011 period and phasing it in incrementally over the 2013 through 2019 periods as farmers adopt the technology. Due to dry subsoil moisture from the 2012 drought, corn yields in 2013 were adjusted down from trend levels. In 2014, yield levels were adjusted back to trend yields plus the step from technology. In 2014, the increase in yields above trend was 4.6 bushels per acre and in 2015 it was 5.8 bushels per acre.

It is important to note that this increase in corn yields was not extended to South America at this time. Issues with intellectual property protection in Argentina regarding corn technologies and other factors suggested that this assumption may not be appropriate at this time.



Biofuels Technology—Lipid Removal from Distiller's Grains

For these scenarios, one of the most important technology developments is the yield improvements in de-oiling distiller's grains. Distillers corn oil (DCO) is non-food grade oil extracted from Distillers [dried]

[3] Based on a July 11, 2012 article released by the Associated Press entitled, "Crop technologies limit corn losses in drought"

grains with solubles (DDGS) by the corn ethanol industry. This oil is of lower quality than that extracted from the corn kernel for the food market. DCO is darker in color, viscous and high in free fatty acid content all of which are indicators of oil degradation making it unsuitable for human consumption.[4]

Although average industry yields are less, demonstrated technology available today suggests corn oil yields per bushel of corn processed from distillers' grains have reached levels as high as 1.3 pounds per bushel approaching fractionation yields of 1.5 pounds per bushel. Increased production of this feedstock will come from a combination of technology adoption and improvement in the yield of oil removed from a bushel of corn. In these scenarios we have assumed that corn oil yields from de-oiled distillers' grains per bushel of corn processed will increase from 0.71 pounds in 2012 to 0.86 pounds by 2017. Other industry analysts believe these assumptions to be conservative and, based upon economic returns to ethanol plant profitability, anticipate removal rates will be 1.5 lbs by 2022.[5]

Feedstock Utilized for Biodiesel Production (Jan to June)

	2012	2013	% change
	million pounds		
Canola Oil*	580	220	-62%
Distillers Corn Oil	264	452	71%
Soybean Oil	2159	2,299	6%
Animal Fats	500	588	18%
Yellow Grease	429	555	29%

** Canola oil consumption estimated for May/Jun 2013*

Source: Monthly Biodiesel Production Report, August 2013

This analysis also assumes that in 2012, 75 percent of all ethanol plants are assumed to be de-oiling distillers' grains and by 2017, 91 percent of all ethanol plants are assumed to have this capability. Oil removed from this process will be utilized for biodiesel production or may be utilized as an energy source in feed markets. However this source of fat is additive in nature to overall supplies, regardless of use, as fats displaced from the feed market (e.g. inedible tallow) would be utilized for biodiesel production.

Industry data supports the increased supplies and use of distillers corn oil for biodiesel production. During the first six months of 2012, the Energy Information Administration estimated 264 million pounds of DCO were utilized for biodiesel production. This volume rose by 71% the first six months of 2013, to 452 million pounds.

Expanding Animals Fats & Yellow Grease Supplies

Animal fats are derived from the rendering process using animal tissues as the raw material. The raw material is a byproduct of the processing of meat animals and poultry. The amount of fat produced is directly related to the species of animal processed and the degree of further processing that is associated with the marketing/distribution of the meat product. Recycled cooking and restaurant greases are collected and processed primarily by the independent rendering sector since it is generally not a practice for packer or processing facilities to process yellow grease.

As reported by ABF Economics (Urbanchuk, 2013), the U.S. has historically exported about a third of

4 Sandra Majoni. "Oil recovery from condensed corn distillers solubles". PhD Dissertation, Iowa State University. 2009. http://udini.proquest.com/view/oil-recovery-from-condensed-corn-pqid:1868390891/

5 Urbanchuk, John. Production and Availability of Animal Fats, Waste Greases and Inedible Plant Oils for Biodiesel Production. 2013.

animal fats and waste grease and oils production. However since the growth in the biodiesel industry over the past five years the share of exports has declined to about 22 percent of production. Trade data extracted from the U.S. International Trade Commission Interactive trade database[6] indicates that the U.S. exported 2,455 million pounds of waste grease and animal fats in 2012 and imported 213 million pounds. This trend is expected to continue leaving more pounds in the U.S. that will be used to produce value added products such as biodiesel. As cited previously, much of the growth of biodiesel production in 2013 can be attributed to increased domestic supplies of distillers corn oil, animal fats, and yellow grease.

Scenario Results

The following paragraphs summarize the results from the two scenarios considered in this analysis. The WAEES biofuels models are developed on a marketing year basis rather than a calendar year basis. Calendar year biodiesel mandates are converted to a marketing year basis and compliance with biofuels mandates is enforced by the model on a marketing year basis rather than a calendar year basis. Unlike fiscal years, marketing years always designate the starting year and ending year. This means that the 2011/2012 marketing year (abbreviated 11/12) for ethanol refers to the Sept 2011 through August 2012 period. Marketing year 2012/13 would most closely correspond to calendar year 2013. The reason the model is designed in this way is because this aligns the biofuels feed stock demands with the crop marketing years. Unfortunately, this does not allow for the specific calendar year comparisons that one would like to have, but the model will still provide accurate relative comparisons across scenarios.

In the tables that follow, the 11/12 marketing year data is historical data, the 12/13 market year data is preliminary data, and the 13/14 through 15/16 data are projections by WAEES based on the assumptions discussed earlier. Each table shows the results for the second scenario which increases the biodiesel mandate from 1.28 billion gallons in 2014 and 2015 to 1.7 billion gallons. The tables also include three columns to the far right labeled "change from baseline level" which show how the scenario values change from the baseline with the higher biodiesel mandate. The primary focus of the results discussion is on marketing years 13/14 and 14/15 which most closely correspond to calendar years 2014 and 2015.

In the first table entitled, "U.S. Biofuel RINs Tracking" the most obvious change is the increase in the biodiesel mandate. Note that marketing year 13/14 reflects 4/12 of the 1.28 billion gallon mandate in 2013 and 8/12 of the 1.7 billion gallon mandate in 2014. Thus compliance is enforced in 13/14 based on a crop year mandate of 1.56 billion gallons. Under the baseline scenario biodiesel production already exceeded mandated levels of production so increasing the mandate resulted in 41 million gallons of additional biodiesel for 13/14. Since biodiesel production also counts towards the advanced mandate, additional biodiesel production results in less imported sugarcane ethanol use for the advanced mandate. The additional biodiesel production displaced 61 million gallons of sugarcane based ethanol production needed to comply with the advanced mandate. The reason a larger amount of sugarcane ethanol production is displaced is because each gallon of biodiesel production earns 1.5 RINs because of biodiesel's higher energy content when compared with ethanol.

Since the 13/14 biodiesel mandate slightly exceeds biodiesel production levels in the baseline, biodiesel RIN values increase by about 0.06 cents per gallon compared with the baseline. Since less sugarcane ethanol is demanded to fill the advanced mandate, advanced RIN prices fall by 2.2 cents per gallon when

[6] http://dataweb.usitc.gov/scripts/user_set.asp

compared with the baseline. Conventional RIN prices fall by 1.3 cents reflecting less ethanol being pushed into flex fuel vehicle use where it must compete with unleaded gasoline on an energy content basis, i.e. ethanol prices must reflect the energy content of ethanol relative to unleaded gasoline.

U.S. Biofuel RINs Tracking

1.7 BG Biodiesel Mandate Scenario Results

Sept/Aug Marketing Year		11/12	12/13	13/14	14/15	15/16	13/14	14/15	15/16
							change from baseline level		
Renewable Fuel Standard (reduced)		14,783	16,100	16,444	16,910	17,731	0	0	0
Advanced biofuels (reduced)	Million Gallons	1,783	2,500	3,177	3,910	4,398	0	0	0
Cellulosic ethanol (waived)	Million Gallons	0	12	25	73	165	0	0	0
Biodiesel	Million Gallons	933	1,187	1,560	1,700	1,700	280	420	420
Biodiesel RFS RINs									
Production	Million Biodiesel Gallons	1,110	1,408	1,445	1,627	1,726	41	45	-4
Carry In	Million Biodiesel Gallons	110	286	189	73	0	0	0	0
Use for biodiesel compliance	Million Biodiesel Gallons	933	1,187	1,560	1,700	1,700	280	420	420
Unused for this mandate	Million Biodiesel Gallons	286	507	73	0	26	-239	-375	-424
of which, carry out	Million Biodiesel Gallons	286	189	73	0	0	0	0	0
of which, demoted to advanced RINs	Million Biodiesel Gallons	0	319	0	0	26	-239	-375	-424
Advanced RFS RINs									
Production	Million RIN Gallons	1,993	2,794	2,962	3,800	4,397	0	0	0
Biodiesel	Million RIN Gallons	1,664	2,112	2,167	2,440	2,588	61	67	-7
Cellulosic	Million RIN Gallons	0	12	25	73	165	0	0	0
Other Advanced Total	Million RIN Gallons	328	669	770	1,287	1,644	-61	-67	7
Sorghum Advanced Ethanol	Million RIN Gallons	0	0	21	63	120	0	-1	-2
Domestic Sugarcane Ethanol	Million RIN Gallons	0	0	0	0	0	0	0	0
Sugarcane Ethanol Imports	Million RIN Gallons	328	669	749	1,224	1,524	-61	-66	8
Butanol	Million RIN Gallons	0	0	0	0	0	0	0	0
Carry In	Million RIN Gallons	330	540	325	110	0	0	0	0
Use for advanced compliance	Million RIN Gallons	1,783	2,500	3,177	3,910	4,398	0	0	0
Unused for this mandate	Million RIN Gallons	540	834	110	0	0	0	0	0
of which, carry out	Million RIN Gallons	540	325	110	0	0	0	0	0
of which, demoted to conventional RINs	Million RIN Gallons	0	509	0	0	0	0	0	0
Total RFS RINs									
Production	Million RIN Gallons	14,756	15,180	15,650	16,067	17,980	9	-9	-5
Biodiesel	Million RIN Gallons	1,664	2,112	2,167	2,440	2,588	61	67	-7
Cellulosic	Million RIN Gallons	0	12	25	73	165	0	0	0
Other Advanced	Million RIN Gallons	328	669	770	1,287	1,644	-61	-67	7
Conventional	Million RIN Gallons	12,764	12,386	12,688	12,267	13,582	9	-9	-5
Carry In	Million RIN Gallons	2,743	2,589	1,637	843	0	0	9	0
Use for total compliance	Million RIN Gallons	14,783	16,100	16,444	16,910	17,731	0	0	0
Unused for this mandate	Million RIN Gallons	2,716	1,669	843	0	249	9	0	-5
of which, carry out	Million RIN Gallons	2,589	1,637	843	0	249	9	0	-5
of which, expired	Million RIN Gallons	126	32	0	0	0	0	0	0
RIN value	Dollars Per RIN Gallon								
Biodiesel RIN	Dollars Per RIN Gallon	1.29	0.92	1.20	1.30	1.21	0.056	0.061	0.001
Advanced RIN	Dollars Per RIN Gallon	0.61	0.68	1.12	1.22	1.21	-0.022	-0.020	0.001
Conventional RIN	Dollars Per RIN Gallon	0.02	0.52	0.52	0.50	0.47	-0.013	-0.010	0.001

One of the most significant changes in the biodiesel industry is the diversity of feedstocks becoming available. Non-edible corn oil refined from distiller's grains (a by-product of ethanol production) and waste vegetable oils and animal fats have quickly become significant sources of feedstocks. These new feedstocks are also less expensive than soybean oil and canola oil reducing the cost of producing biodiesel and shifting the supply curve for biodiesel outward representing a more efficient industry. The biodiesel supply and use table below reflects the levels of biodiesel production expected under the 1.7 billion gallon biodiesel mandate. The impacts of the scenario are very minimal with stronger biodiesel production resulting in very small increases in soybean oil prices which are offset by higher biodiesel prices in 13/14 and 14/15. In 15/16, there is a very slight decline in biodiesel production which results from slightly higher feedstock costs.

U.S. Biodiesel Supply and Use
1.7 BG Biodiesel Mandate Scenario Results

Oct/Sep Marketing Year		11/12	12/13	13/14	14/15	15/16	13/14	14/15	15/16
							change from baseline levels		
Policy - MY Approximation									
Biodiesel Mandate	Million Gallons	933	1,187	1,560	1,700	1,700	280	420	420
Biodiesel Blenders Tax Credit	Dollars Per Gallon	1.00	1.00	0.25	0.00	0.00	0	0	0
Production Capacity (MY average)	Million Gallons	2,686	3,062	3,526	3,876	4,087	8	11	20
Supply									
Total Production	Million Gallons	1,182	1,349	1,354	1,525	1,618			
Methyl Ester Production	Million Gallons	1,100	1,136	1,051	1,205	1,298	39	43	-5
By Feedstock									
Soybean Oil	Million Gallons	632	597	515	635	690	30	36	-6
Corn Oil	Million Gallons	65	143	144	162	200	0	0	0
Canola Oil	Million Gallons	125	84	60	66	60	4	6	1
Other Fats and Oils	Million Gallons	278	311	333	342	349	6	1	0
Inedible Tallow	Million Gallons	51	59	76	82	87	2	0	0
Lard & White Grease	Million Gallons	57	67	70	70	70	0	0	0
Yellow Grease	Million Gallons	74	88	90	91	92	1	0	0
Brown Grease	Million Gallons	34	36	35	35	34	0	0	0
Poultry Fat	Million Gallons	24	27	27	30	32	1	0	0
Other	Million Gallons	37	34	34	34	34	0	0	0
Renewable Diesel Production & Net Imports*	Million Gallons	82	213	303	320	320			
Disappearance	Million Gallons	1,086	1,405	1,443	1,617	1,721	39	45	-2
Net Exports (methyl esters)	Million Gallons	73	-60	-91	-102	-107	-1	-2	0
Ending Stocks**	Million Gallons	78	81	82	92	97	2	2	0
Fuel Prices & Ratios									
#2 Diesel, Refiner Sales	Dollars Per Gallon	3.09	2.83	2.73	2.77	2.86	0.00	0.00	0.00
#2 Diesel, Retail	Dollars Per Gallon	3.93	3.71	3.62	3.67	3.77	0.01	0.00	0.00
Biodiesel, FOB Plant, Iowa	Dollars Per Gallon	4.75	4.56	4.22	4.07	4.02	0.07	0.07	0.00
Biodiesel, Retail Price Equivalent	Dollars Per Gallon	1.81	2.18	2.18	2.13	2.21	-0.02	-0.02	0.00
Ratio of Biodiesel Retail Price to #2 Diesel Retail Price	Ratio	0.46	0.59	0.60	0.58	0.59	-0.01	-0.01	0.00
Costs and Returns									
Biodiesel Value	Dollars Per Gallon	4.75	4.56	4.22	4.07	4.02	0.07	0.07	0.00
Glycerin Value	Dollars Per Gallon	0.08	0.08	0.08	0.08	0.08	0.00	0.00	0.00
Less Soybean Oil Cost	Dollars Per Gallon	-3.92	-3.70	-3.55	-3.35	-3.31	-0.05	-0.05	-0.01
Less Other Operating Costs	Dollars Per Gallon	-0.38	-0.38	-0.39	-0.39	-0.39	0.00	0.00	0.00
Net Operating Return	Dollars Per Gallon	0.53	0.56	0.37	0.41	0.40	0.02	0.02	0.00

* Includes on the renewable diesel eligible for D4 RINs. Renewable diesel historical estimates based on EPA EMTS data. Projections based on industry experts.
** Ending stocks data adjusted from EIA numbers to make supply and demand balance

Soybean oil prices increase less than 0.7 cents per pound under the 1.7 billion gallon scenario when compared with the baseline, but slight higher soybean oil prices result in slightly more soybean crush. Larger crush results in more soybean meal production which cause soybean meal prices to fall slight which benefits the livestock sector.

U.S. Soybean Products Supply and Utilization
1.7 BG Biodiesel Mandate Scenario Results

Oct/Sep Marketing Year	Units	11/12	12/13	13/14	14/15	15/16	13/14	14/15	15/16
							change from baseline levels		
Soybean Meal									
Supply	1000 Short Tons	41,591	40,150	40,701	43,611	44,943	30	107	24
Beginning Stocks	1000 Short Tons	350	300	300	297	320	0	0	1
Production	1000 Short Tons	41,025	39,500	40,236	43,148	44,458	30	106	23
Imports	1000 Short Tons	216	350	165	165	165	0	0	0
Domestic Use	1000 Short Tons	31,550	29,350	30,229	31,656	32,667	24	79	21
Exports	1000 Short Tons	9,741	10,500	10,175	11,634	11,946	6	27	3
Total Use	1000 Short Tons	41,291	39,850	40,404	43,290	44,613	30	105	25
Ending Stocks	1000 Short Tons	300	300	297	320	331	0	1	0
Price, 48% Protein, Decatur	Dollars Per Short Ton	393.53	455.00	315.88	273.40	255.84	-0.85	-2.45	-0.68
Soybean Oil									
Supply	Million Pounds	22,315	22,495	21,376	22,825	23,553	15	21	-22
Beginning Stocks	Million Pounds	2,425	2,540	1,745	1,792	1,888	0	-30	-33
Production	Million Pounds	19,740	19,605	19,381	20,784	21,414	15	51	11
Imports	Million Pounds	149	350	250	250	250	0	0	0
Domestic Use	Million Pounds	18,310	18,550	17,698	18,865	19,255	167	218	-50
Biodiesel	Million Pounds	4,870	4,600	3,965	4,890	5,310	228	281	-44
Food and Other	Million Pounds	13,440	13,950	13,733	13,975	13,945	-61	-63	-6
Exports	Million Pounds	1,464	2,200	1,887	2,072	2,379	-122	-164	32
Total Use	Million Pounds	19,775	20,750	19,584	20,937	21,634	45	54	-18
Ending Stocks	Million Pounds	2,540	1,745	1,792	1,888	1,919	-30	-33	-4
Price, Decatur	Cents Per Pound	51.90	48.00	46.10	43.48	42.95	0.63	0.67	0.08

Soybean farm prices increase $0.04 per bushel as a result of increased crush demand in 13/14. Slight strong soybean prices results in 0.2 million acres more soybeans in 14/15 with no difference in soybeans prices in 14/15 from baseline levels.

U.S. Soybean Supply and Utilization

1.7 BG Biodiesel Mandate Scenario Results

Sept/Aug Marketing Year	Units	11/12	12/13	13/14	14/15	15/16	13/14	14/15	15/16
							change from baseline levels		
Area									
Planted Area	Million Acres	75.0	77.2	77.7	75.3	73.8	0.0	0.2	0.0
Harvested Area	Million Acres	73.8	76.1	76.9	74.5	73.0	0.0	0.2	0.0
Harvested Area % of Planted	Percent	98.3%	98.6%	98.9%	98.9%	98.9%			
Yield	Bushels Per Acre	41.9	39.6	44.5	46.2	47.2	0.0	0.0	0.0
Supply	Million Bushels	3,325	3,209	3,560	3,753	3,797	0	7	0
Beginning Stocks	Million Bushels	215	169	125	298	339	0	-1	0
Production	Million Bushels	3,094	3,015	3,420	3,441	3,443	0	8	0
Imports	Million Bushels	16	25	15	15	15	0	0	0
Domestic Use	Million Bushels	1,793	1,754	1,811	1,941	2,000	1	5	1
Crush	Million Bushels	1,703	1,660	1,690	1,812	1,867	1	4	1
Seed, Residual	Million Bushels	90	94	121	129	133	0	0	0
Exports	Million Bushels	1,362	1,330	1,452	1,473	1,444	0	1	0
Total Use	Million Bushels	3,155	3,084	3,262	3,413	3,444	1	6	1
Ending Stocks	Million Bushels	169	125	298	339	354	-1	0	0
Prices, Ratios, and Margins									
Farm Price	Dollars Per Bushel	12.50	14.40	10.59	8.81	8.40	0.04	0.00	0.00
Illinois Processor Price	Dollars Per Bushel	13.69	15.42	11.72	9.99	9.59	0.04	0.00	0.00
Soybean-To-Corn Price Ratio	Ratio	2.01	2.07	2.25	2.16	2.03	0.01	0.00	0.00
Crushing Margin	Dollars Per Bushel	1.81	1.07	1.08	1.50	1.42	0.01	0.02	0.00
Returns									
Gross Market Returns	Dollars Per Acre	524.14	570.48	471.34	407.15	395.99	1.99	-0.17	-0.22
Variable Expenses	Dollars Per Acre	138.94	144.36	146.69	150.24	153.24	0.00	0.00	0.00
Market Returns over Variable Costs	Dollars Per Acre	385.20	426.12	324.65	256.92	242.75	1.99	0.17	0.22
Government Subsidies									
Loan Deficiency Payments	Dollars Per Acre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Counter Cyclical Payments	Dollars Per Base Acre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Direct Payments	Dollars Per Base Acre	11.56	11.56	11.56	0.00	0.00	0.00	0.00	0.00

Biodiesel production is also closely related to ethanol production through competition for crop acres but particularly through sugarcane ethanol imports which compete with biodiesel for the advanced mandate. As the advanced mandate increases, both sugarcane ethanol imports and U.S. biodiesel production grows to fill the advanced mandate. In the 1.7 billon gallon scenario, imports of sugarcane ethanol are reduced because biodiesel fills more of the advanced mandate. Less ethanol in the U.S. market means that less flex fuel vehicle consumption is needed. The importance of this change is that ethanol used in flex fuel vehicles must compete with unleaded gasoline on an energy equivalent basis, i.e. lower retail ethanol prices. With less ethanol going to flex fuel vehicles, implied retail prices of ethanol are slightly higher reducing conventional RIN prices. Ethanol exports back to Brazil are also slightly lower since less sugarcane ethanol is imported from Brazil. The drop in the ratio of ethanol to unleaded gasoline prices between 12/13 and 13/14 reflects the change necessary to incentivize higher ethanol blend consumption.

Ethanol Supply and Use
1.7 BG Biodiesel Mandate Scenario Results

Sep/Aug Marketing Year		11/12	12/13	13/14	14/15	15/16	13/14	14/15	15/16
							change from baseline levels		
Policy									
Starch Based Mandate (MY Approximation)	Million Gallons	13,000	13,600	13,267	13,000	13,333	0	0	0
Crude Oil Prices									
West Texas Intermediate Price	Dollars Per Barrel	102.09	91.96	92.08	93.56	97.23	0	0	0
Refiners Acquisition Price	Dollars Per Barrel	110.35	99.92	100.03	101.45	104.98	0	0	0
Supply	Million Gallons	14,992	14,405	15,020	15,645	17,499			
Beginning Stocks	Million Gallons	761	813	766	832	850			
Production	Million Gallons	13,790	12,848	13,430	13,515	15,051	-22	-40	-8
From Corn	Million Gallons	13,662	12,720	13,218	13,295	14,639	-19	-36	-6
From Other Feedstocks	Million Gallons	128	116	188	147	247	-2	-4	-3
Cellulosic	Million Gallons	0	12	25	73	165	0	0	0
Imports	Million Gallons	440	744	823	1,298	1,598	-61	-66	8
Disappearance	Million Gallons	13,092	13,067	13,483	13,627	15,391	-53	-76	2
Low Level Blends	Million Gallons	12,983	12,959	13,253	13,143	12,812	7	12	0
Flex Fuel Vehicles	Million Gallons	109	108	229	484	2,579	-60	-87	2
Exports	Million Gallons	1,086	571	704	1,168	1,179	-29	-29	-3
Ending Stocks	Million Gallons	813	766	832	850	929	-1	-2	0
Fuel Prices & Ratios									
Unl. Gasoline, FOB Omaha	Dollars Per Gallon	2.91	2.82	2.73	2.72	2.74	0.00	0.00	0.00
Unleaded Gasoline, Retail	Dollars Per Gallon	3.58	3.49	3.41	3.40	3.43	0.00	0.00	0.00
Ethanol, FOB Omaha	Dollars Per Gallon	2.46	2.50	1.97	1.80	1.79	0.00	0.00	0.00
Ethanol, Retail Price Equivalent	Dollars Per Gallon	2.97	3.15	2.13	1.98	2.02	0.01	0.00	0.00
Ratio of Retail Prices: Ethanol to Unleaded Gasoline	Ratio	0.83	0.90	0.63	0.58	0.59	0.00	0.00	0.00

In summary, the change resulting from an increase in the biodiesel mandate from 1.7 to 1.28 billion gallons has relatively small impacts increasing the cost of biodiesel RINs but decreasing the cost of advanced RINs and conventional RINs. Slightly less sugarcane ethanol is imported and more domestic production of biodiesel occurs.

Comparing the "Baseline" and 1.7 Billion Gallon Mandate Scenarios

The cost of the increase in the biomass-based diesel volume obligation can be evaluated based on the RIN values associated with the biofuels that are available to meet the advanced mandate which include biodiesel and sugarcane ethanol and any impacts on conventional RIN values. In the baseline scenario, biodiesel RIN production already exceeds mandated levels of production so the increase in biodiesel production from increasing the biodiesel mandate is 39 million gallons in 13/14 and 43 million gallons in 14/15. But the biodiesel RIN price does increase and that cost applies to all gallons of biodiesel production.

The table below presents the impacts on direct compliance costs of increasing the biodiesel mandate. The top 1/3 of the table shows the increased compliance costs associated with the change in policy from a 1.28 billion gallon biodiesel mandate in the baseline to a 1.7 billion gallon mandate in the scenario. The costs primarily arise from slight higher RIN prices needed to incentivize biodiesel production and a slightly larger biodiesel production. In 2013/14 the cost of compliance und the 1.7 billion gallon mandate scenario is 2.167 billion RIN gallons (1.56 billion biodiesel gallons * 1.5 RINs/gallon) multiplied by the biodiesel RIN price of $1.20 per gallon for a product of 2.596 billion dollars. This is contrasted with the cost of compliance under the baseline scenario where the biodiesel mandate was 1.28 billion gallons. Biodiesel RINs produced under the baseline scenario were 2.106 billion and the biodiesel RIN price was $1.14 per gallon resulting in a product of 2.404 billion gallons. The additional cost spent on biodiesel RINs in 2013/14 is 192 million dollars.

RIN Compliance Costs With and Without a Change in Biodiesel Mandates

Marketing Year	2013/14	2014/15
Cost of Compliance with a 1.7 billion gallon mandate for biodiesel beginning in 2014		
Biodiesel Production	*million ethanol gallons*	
1.7 BG Biodiesel Mandate Scenario	2,167	2,440
Baseline Scenario	2,106	2,373
Biodiesel RIN Prices	*dollars per gallon*	
1.7 BG Biodiesel Mandate Scenario	1.20	1.30
Baseline Scenario	1.14	1.23
Cost of biodiesel RINs	*million dollars*	
1.7 BG Biodiesel Mandate Scenario	2,596	3,161
Baseline Scenario	2,404	2,930
Change in Cost of Biodiesel RINS	192	231
Cost of Compliance under the Baseline		
Sugarcane Ethanol Used to Comply With Advanced Mandate	*million ethanol gallons*	
Baseline Scenario	810	1,290
1.7 BG Biodiesel Mandate Scenario	749	1,224
Advanced RIN price	*dollars per gallon*	
Baseline Scenario	1.14	1.23
1.7 BG Biodiesel Mandate Scenario	1.12	1.22
Cost of sugarcane ethanol RINs	*million dollars*	
Baseline Scenario	924	1,593
1.7 BG Biodiesel Mandate Scenario	838	1,487
Change in Cost of Advanced RINS	86	106
Starch Based Ethanol Used for Compliance less carryover	*million ethanol gallons*	
Baseline Scenario	12,679	12,276
1.7 BG Biodiesel Mandate Scenario	12,688	12,267
Conventional Ethanol RIN Prices	*dollars per gallon*	
Baseline Scenario	0.53	0.51
1.7 BG Biodiesel Mandate Scenario	0.52	0.50
Cost of conventional RINs	*million dollars*	
Baseline Scenario	6,747	6,296
1.7 BG Biodiesel Mandate Scenario	6,593	6,168
Change in Cost of Convential RINs	154	128
	million dollars	
Cost savings with policy change to 1.7 bg of biodiesel	**48**	**2**
#2 Diesel Sales to On-Highway Consumers*	38,869	41,644
Cost savings per gallon of diesel consumed	0.0064	0.0093

* Source: DOE/EIA Annual Energy Outlook 2013 Early Release, Transportation Sector Energy Use by Fuel Type Within a Mode, Reference Case
Includes light duty vehicles, commercial light trucks, freight trucks, transit buses, intercity buses, and school buses.

However there is offsetting compliance cost savings on the advanced mandate and conventional mandate side. With lower demand for imported sugarcane ethanol, the value of the advanced RIN falls by 2 cents per gallon. The cost of compliance for the sugarcane ethanol used to meet the advanced mandate falls from 924 million dollars in the baseline to 838 million dollars in under the 1.7 billion gallon mandate scenario for a savings of 86 million dollars. There is also a savings on the conventional ethanol side because conventional ethanol RINs prices also decline since less ethanol is pushed into flex fuel vehicles where ethanol must compete on an energy equivalent basis with unleaded gasoline. While there is virtually no change in conventional ethanol used for compliance, the conventional RIN value falls slightly resulting in savings of 154 million dollars in 2013/14.

This analysis suggests that the direct cost of biodiesel RINs from increasing the biomass-based diesel volume obligation in 2013/14 is $192 million. However, this cost is offset by the savings in the cost of sugarcane ethanol advanced RINS of $86 million as well as the savings in cost of convention RINs of $154 million. This suggests that the policy change to 1.7 billion gallons of biodiesel in 2014 has a cost savings $48 million in 2013/14. Continuation of the 1.7 billion gallon mandate in 2015, results in $2 million dollars in 2014/15.

Direct Employment Impacts of the 2017 1.7 Billion Gallon Biodiesel Mandate Scenario

Direct benefits from increasing the 2014 volume obligation for biomass-based diesel fuel will be provided by the economic activity associated with producing the additional fuel. Specifically, increasing the volume obligation will support almost 1,900 additional direct jobs in the economy (total of 15,123 direct jobs supported by a 1.7 billion gallon industry). These jobs are associated with both the production of the additional 420 million gallons of biomass-based diesel fuel as well as the fats and oils required as feedstock, and transporting both feedstock and finished diesel fuel. For this portion of the analysis, the impact across the value chain for U.S.-produced biodiesel (see table on the following page) was established via three different metrics:

- **Economic impact** — quantifying the value added to the US economy across the biodiesel value chain.
- **Employment impact** — estimating the number of full-time equivalent (FTE) jobs contributed by biodiesel production, processing and distribution.
- **Wage impact** — evaluating the total wages for individuals employed along the biodiesel value chain.

The economic indicators for each step of the biodiesel value chain are evaluated at three different levels, Direct, Indirect and Induced:

- As the name suggests, the **Direct effect** is composed of the economic, employment and wage impacts that can be directly attributed to the biodiesel value chain. *These results were calculated first hand by LMC International based on models driven by publicly and privately available data, industry knowledge, and interviews with industry stakeholders.*
- **Indirect effects** are the economic, employment and wage impacts created by those industries that supply the biodiesel value chain, or by individuals who work at the periphery of the sector.
- **Induced effects** are those economic, employment and wage impacts that stem from household spending of the income earned from the biodiesel sector.

Direct economic impacts of biodiesel production are manually evaluated across 11 steps in the value chain — spanning from the production of feedstocks produced specifically for biodiesel production to delivery of biodiesel to the point of sale. The model also allocates impacts across all 50 states, based primarily on these states' share of 1) feedstock production and 2) processing capacity for biodiesel. An understanding of state-level production and demand is particularly important when it comes to determining impacts on transportation.

Based upon this analysis, increasing the biomass-based diesel fuel volume obligation from 1.28 billion gallons to 1.7 billion gallons would result in almost 1,900 additional jobs supported by the biodiesel industry, more than $96 million in additional wages, and more than $2 billion in additional economic activity.

The Biodiesel Value Chain

Value Chain Component	Description
Seed Production	Value of the oil produced for biodiesel feedstock in seed. Given that meal is outside the scope of the biodiesel chain its value is excluded
Animal Processing	Processing and rendering of animal carcasses into feedstocks for biodiesel use
Seed Delivery	Delivery of seeds used in biodiesel to elevation facility
Elevation	Elevation and storage of seeds used in biodiesel production
Oilseed crush (oil share)	Value in removing oil from seed in crush process for use as a biodiesel feedstock
Biodiesel Processing	Collection and processing of feedstocks into biodiesel
Rail deliveries of biodiesel and glycerin for domestic market	Rail shipments of biodiesel and glycerin from surplus to deficit states with most traffic originating in the Midwest
Rail deliveries of biodiesel for export market	Rail shipment of biodiesel to point of export from the US
Barge deliveries	Barge deliveries (primarily from Midwest to Houston) and primarily for the export market
Port activities	Loading ocean-going vessels with biodiesel for shipments to the export market
Trucking to point of sale	Trucking of biodiesel (mostly blended with conventional diesel) from terminal to dealer outlet

Indirect Impacts of Increased Biodiesel Production & Sales

In addition to direct employment benefits and a cost savings for U.S. consumers, increasing the 2014 volume obligation for biomass-based diesel fuel also has several indirect/ancillary benefits. Specifically, increased production of biodiesel increases the global fuel supply, there are indirect and induced employment impacts associated with increased biodiesel production, and energy security and health benefits accrue to U.S. citizens.

Indirect & Induced Economic Impacts

The direct effects previously cited of increased biodiesel production on the U.S. economy are significant, but they fail to capture the full impact of the sector.

- There is a ripple effect that the biofuel has on supporting industries. This is known as the indirect effect. For some steps in the biodiesel value chain, the indirect effect can be quite large. This is especially true for capital-intensive aspects of the sector, like crushing of oilseeds and refining crude oil to a usable fuel. To illustrate this point, consider the typical biodiesel facility in the U.S., with an average capacity of 40-60 million gallons annually, which *directly* employs between 40 and 50 people (*although there is considerable variation across the capacity and staffing rates of the country's 100+ operational facilities*). This does not include the many jobs associated with keeping that facility operational, from white collar jobs in engineering to trade professions like electricians, plumbers and pipefitters, that are done on a contractual basis, making the true impact of that facility much higher.

- Similarly, direct effects fail to capture the economic activity stemming from expenditures of households drawing a salary from a given sector. While these "induced" effects are typically smaller than indirect effects, they can still constitute a sizeable economic force, particularly when the sector being evaluated is large, as is the case for biodiesel.

To capture indirect and induced effects, economists use multipliers, which are developed from "input-output" tables, which in turn measure the impact on the broader economy from some kind of exogenous shock to a specific sector of the economy. Because input-output tables and economic multipliers are the convention when estimating indirect and induced effects, they are available for many economies globally. In the case of the United States, multipliers are made available by the U.S. Department of Commerce's Bureau of Economic Analysis across 406 detailed industries and, in most cases, all 50 states. The table below presents the most important multipliers used in this study, along with the industry classification NAICS code. These multipliers are applied to our manually calculated direct effects to capture indirect and induced effects.

Based upon analysis conducted by LMC International, Inc., increasing the biomass-based diesel fuel volume obligation to 1.7 billion for 2014 will account for an <u>additional</u> $2.54 billion of GDP, $223.7 million of household income. and 5,428 jobs above the direct effects previously cited (indirect and inducted impacts).

Combined with direct impacts, a 1.7 billion gallon market is expected to support a total of 59,305 jobs, $16.78 billion in economic activity, and $2.5 billion in wages.

<u>Energy Security Impacts</u>

As detailed in the March 26, 2010 RFS Final Rule, EPA conducted multiple economic analysis to assess the impacts of energy security from increased use of biofuels. EPA used the Oil Security Metrics Model (OSMM), developed and maintained by Oak Ridge National Laboratory (ORNL) to examine the future economic costs of oil imports and oil supply disruptions to the U.S. Their approach emphasizes energy-security related costs which are not reflected in the market price of oil, and which are expected to change in response to an incremental change in the level of oil imports. Omitted from their analyses are environmental costs and possible non-economic or unquantifiable effects, such as effects on foreign policy flexibility or military policy.

As noted in the 2007 ORNL analysis, "Concerns about oil security stem from three related problems: concentrated supply in a historically unstable region; the exercise of market power by key oil exporters; and the continued (although perhaps diminished) vulnerability of the economy to oil supply shocks and price spikes." The authors of the ORNL analysis highlight that in addition to the purchase price of crude oil, the full economic costs of importing petroleum into the U.S. include:

- Higher costs for oil imports resulting from the effect of U.S. import demand on the world oil price and OPEC market power,
- the risk of reductions in U.S. economic output and disruption of the domestic economy caused by sudden disruptions in the supply of imported oil to the U.S., and
- costs of existing policies meant to enhance oil security.

EPA has also noted, "[e]nergy security does not solely relate to the amount of imported oil but also to the ability of the U.S. to diversify and rely on domestic sources of energy to meet the energy needs of the U.S. ...Therefore, 'regardless of the incremental effect of this proposal on net imports, increasing the diversification of the U.S. and global diesel fuel pools would likely confer some reduction in the severity of a future potential disruption in the world oil market.'"

Two of the three components are addressed in the ORNL analysis; monopsony power and the economic costs associated with the disruption of world oil supplies.

> Monopsony Power—Because the U.S. is a larger purchaser of petroleum oil, our imports (or lack thereof) can impact the world price for crude. Reduced imports by the United States could lead to a reduction in crude oil prices globally.
>
> Costs of Supply Disruptions—Another economic cost results from the effect of oil use on the expected cost of disruptions. A sudden increase in oil prices triggered by a disruption in world oil supplies will reduces the level of output that the U.S. economy can produce using its available resources and can cause temporary dislocation and underutilization of available resources, such as labor unemployment and idle plant capacity.

When analyzing impacts of modifying the 2013 volume obligation for biomass-based diesel fuel, EPA based part of their analysis on historical and projected future variation in U.S. petroleum consumption and imports and estimated that approximately 50% of the reduction in fuel consumption resulting from adopting renewable fuels is likely to be reflected in reduced U.S. imports of refined fuel, while the remaining 50% is expected to be reflected in reduced domestic fuel refining. Of the latter, 90% was anticipated to reduce U.S. imports of crude petroleum for use as a refinery feedstock, while the remaining 10% was expected to reduce U.S. domestic production of crude petroleum. EPA then estimated each gallon of fuel saved due to the RFS reduces total U.S. imports of petroleum by 0.95 gallons.

ORNL estimates the incremental benefits to society in units of dollars per barrel by reducing US imports. The most recently available results from ORNL analysis regarding the monetized benefits of decrease oil imports are shown in the table below for the years 2013 and 2022.

Energy Security Premium for 2013 and 2022 (2010 $ per barrel)

Economic Component	2013 Mean	2013 Range	2022 Mean	2022 Range
Monopsony Power	11.4	3.83 - 19.40	9.82	3.27-16.77
Costs of Supply Disruptions	7.13	3.41-10.35	7.84	3.80-11.30
TOTAL	**18.53**	**10.03-26.74**	**17.66**	**9.88-24.99**

Source: Leiby, EPA-HQ-OAR-201-0133-0252, Sep 2012

Based upon the ORNL work performed in 2012 and combined with EPA methodology regarding the percent of imported finished product versus crude, an increase of the biomass-based diesel fuel volume obligation to 1.7 billion gallons (versus 1.28 billion gallons) would result in more than $163 million in energy security benefits. This equates to, on average, 39¢ per gallon of benefit for every gallon of biodiesel increase (range of 15¢ to 62¢ per gallon).

Health Benefits

Biodiesel has numerous environmental benefits, including reducing greenhouse gas (GHG) emissions. Biodiesel is an environmentally safe fuel, and is the most viable transportation fuel when measuring its carbon footprint, life cycle and energy balance.

The lifecycle analysis conducted by EPA found that biodiesel reduces GHG emissions by as much as 86 percent when compared to petroleum diesel fuel. The U.S. Department of Agriculture (USDA)/Department of Energy (DOE) lifecycle study shows a 78 percent reduction in direct lifecycle CO_2 emissions for B100. *See* John Sheehan, *et al., An Overview of Biodiesel and Petroleum Diesel Life Cycles*, NREL/TP-580-24772, at 18 (May 1998), *available at* http://www.nrel.gov/docs/legosti/fy98/24772.pdf. Argonne National Laboratory currently quantifies biodiesel's well to wheel GHG benefit being as high as 122 percent compared to average petroleum diesel. As such, EPA cannot contend that an increase in Biomass-based Diesel would "have essentially no impact on climate change in the context of the full mix of biofuels used to meet the RFS2 requirements." 76 Fed. Reg. at 38,869. Even if such is the case, the substantially greater emissions reductions associated with biodiesel would support an even higher applicable volume than 1.7 billion gallons.[7]

Biodiesel's emissions significantly outperform petroleum-based diesel. Research conducted in the United States shows biodiesel emissions have decreased levels of all target polycyclic aromatic hydrocarbons (PAH) and nitrited PAH compounds, as compared to petroleum diesel exhaust. These compounds have been identified as potential cancer causing compounds. Biodiesel is the only alternative fuel to voluntarily perform EPA Tier I and Tier II testing to quantify emission characteristics and health effects. That study found that B20 (20 percent biodiesel blended with 80 percent petroleum diesel fuel) provided significant reductions in total hydrocarbons; carbon monoxide; and total particulate matter. Research also documents the fact that the ozone forming potential of the hydrocarbon emissions of pure biodiesel is nearly 50 percent less than that of petroleum fuel. Biodiesel production also has been found to produce less smog forming emissions than petroleum diesel production. Pure biodiesel typically does not contain sulfur and, therefore, reduces sulfur dioxide exhaust from diesel engines to virtually zero.

Although the final rule and Regulatory Impact Analysis quantify the overall benefits of the RFS, the specific health benefits to consumers for biodiesel have not been individually estimated for this analysis. Public health benefits will be in addition to the economic benefits quantified in this report.

[7] EPA estimated as much as 86% GHG reductions for biodiesel compared to a high of 71% GHG reductions for sugar ethanol -- what EPA considers to be the second most likely Advanced Biofuel to be used.

Summary of Impacts Associated with Increasing the Biomass-based Diesel Fuel Volume Obligation to 1.7 Billion Gallons in 2014

Economic Impacts (Benefits) Associated with Increasing the Biomass-based Diesel Volume Obligation to 1.7 Billion Gallons in 2014.

Annual Direct Economic Impacts			
Changes in RIN Program Compliance Costs			*mil dollars*
	Net Estimated Impact (Savings) for Oct 2013 to Sep 2014		**$48**
Annual Direct Economic Impacts*			
Jobs		**1,890**	
	Increased Wages (Mil $)		**$96.1**
	Increased GDP (Mil $)		**$2,009.0**

** Additional economic benefits from increasing biodiesel production by 420 million gallons*

Annual Indirect Impacts of Increasing the Production and Sales of Biodiesel 420 Million Gallons^

Indirect & Induced Economic Impacts*			*mil dollars*
	Jobs	5,428	
	Increased GDP (Mil $)		$2,538.0
	Increased Wages (Mil $)		$223.7
Energy Security Benefits			$163.0

** Additional economic benefits from increasing biodiesel production by 420 million gallons*

^ Estimates do not include health impacts (benefits)

ABF *Economics*
Agriculture and BioFuels Consulting, LLP

PRODUCTION AND AVAILABILITY OF ANIMAL FATS, WASTE GREASES AND INEDIBLE PLANT OILS FOR BIODIESEL PRODUCTION

Prepared for
Renewable Energy Group

John M. Urbanchuk
Managing Partner

August 8, 2013

EXECUTIVE SUMMARY

The U.S. biodiesel industry has grown from actual production of 450 million gallons in 2007 to more than 1.1 billion gallons in 2012 and is poised to exceed 1.3 billion gallons in 2013. This growth has been due in large part to the availability of soybean and canola oils that have historically been the primary feedstocks for biodiesel production. The continuing supply of these oilseed feedstocks have benefitted from yield growth that has resulted from improved genetics and agronomic practices including double cropping and rotations. These positive developments will continue to add to the future availability of these byproducts. Also, as the Renewable Fuel Standard (RFS) program has grown there has been a significant and corresponding growth in biodiesel production. In particular, increased demand for biomass-based diesel Renewable Identification Numbers[1] (RINs) has stimulated interest in the use of additional alternative feedstocks for biodiesel production.

The objective of this study is to estimate and project the production and availability of the following alternative feedstocks (hereafter collectively waste fats, oils, and greases, or "FOG") for biodiesel production:

- Inedible corn oil (ICO or "distillers corn oil" from the ethanol industry)
- Beef tallow, pork lard, and poultry fat

[1] RINs provide the principal compliance mechanism for tracking the production and use of renewable fuels pursuant to RFS volumetric production requirements for renewable fuels in the U.S. Biodiesel and renewable diesel, both of which utilize fats, oils, and greases as feedstocks, qualify for the generation of biomass-based diesel RINs under the advanced biofuel feedstock requirements of the RFS.

- Recycled cooking oil ("yellow grease")
- Waste or trap grease ("brown grease")
- Inedible plant oils

. The results of this study indicate that in the near future there will be sufficient quantities of FOG feedstocks alone to produce nearly 1.5 billion gallons of biodiesel. This represents an increase in projected FOG feedstock production of more than 50 percent over current supply – from an estimated 12.7 billion pounds in 2012 to nearly 19.4 billion pounds by 2022.

The most significant growth in FOG feedstocks is expected in waste grease (both yellow and brown) and ICO due to increased recovery and improved yields resulting from new technology.

Increased recovery of ICO from the ethanol production process represents a key development in FOG supply. Recovery of ICO currently adds 6 to 8 cents per gallon of revenue for a dry mill corn ethanol producer, and penetration of ICO extraction and recovery capability is projected to increase from an estimated 75 percent of dry mills today to more than 90 percent by 2022. In addition, the development of new extraction technologies is expected to further increase ICO yields significantly by 2022. The recovery of inedible oil from other ethanol feedstocks such as sorghum is expected to further bolster supply.

Increased supply of ICO (and sorghum oil) is expected to directly benefit the biodiesel market. Demand for fats and oils for use as a component of animal feed is already being met by other waste greases and oils, and any substitution for these feedstocks will result in a net increase available to biodiesel that is equal to the ICO increase. Consequently, additional growth in feedstock supply from ICO will largely be used for biodiesel production.

Historically, the U.S. has exported approximately one third of FOG produced domestically. However, with the growth in the biodiesel industry over the past five years, FOG exports have declined to approximately 22 percent of production. This trend is expected to continue, leaving more pounds of FOG available for the domestic production of value-added products such as biodiesel.

Canada produced an estimated 2.1 billion pounds of FOG in 2012. If even half of this output was used by Canadian bio refineries, it would fully meet projected biodiesel feedstock demand in Canada.

However, the Canadian biodiesel industry is moving toward increased use of canola oil as a feedstock, reflecting concerns about cold flow properties of biodiesel in northern climates, and is targeting the U.S. as an export market for FOG. As a consequence, FOG consumption in Canada is likely to decline over time, increasing potential FOG supplies available for export to the U.S.

According to the EIA, FOG accounted for approximately 30 percent of biodiesel feedstocks in 2011 and nearly 34 percent in 2012. As a result of increased availability and slower growth in feed and industrial uses, we expect the share of these feedstocks available for biodiesel to increase from approximately 34 percent to 58 percent and be sufficient by themselves to produce nearly 1.5 billion gallons of biodiesel by 2022.

ABF *Economics*

Agriculture and BioFuels Consulting, LLP

PRODUCTION AND AVAILABILITY OF ANIMAL FATS, WASTE GREASES, AND INEDIBLE PLANT OILS FOR BIODIESEL PRODUCTION

Prepared for
Renewable Energy Group

John M. Urbanchuk
Managing Partner

August 8, 2013

The U.S. biodiesel industry has grown from actual production of 450 million gallons in 2007 to more than 1.1 billion gallons in 2012 and is poised to exceed 1.3 billion gallons this year. This growth has been due in large part to the availability of soybean and canola oils that have historically been the primary feedstocks for biodiesel production. The continuing supply of these oilseed feedstocks have benefitted from yield growth that has resulted from improved genetics and agronomic practices including double cropping and rotations. These positive developments will continue to add to the future availability of these byproducts. As the Renewable Fuel Standard (RFS) program has grown there has been a significant and corresponding growth in biodiesel production. In particular, increased demand for biomass-based diesel Renewable Identification Numbers[2] (RINs) has stimulated interest in the use of additional alternative feedstocks for biodiesel production, including the following (hereafter collectively waste fats, oils, and greases, or "FOG").

- Inedible corn oil (ICO or "distillers corn oil" from the ethanol industry)
- Beef tallow, pork lard, and poultry fat
- Recycled or used cooking oil (UCO or "yellow grease")
- Waste or trap grease ("brown grease")
- Inedible plant oils

In order to meet the country's renewable energy objectives, the U.S. can draw upon its plentiful fats,

[2] RINs provide the principal compliance mechanism for tracking the production and use of renewable fuels pursuant to RFS volumetric production requirements for renewable fuels in the U.S. Biodiesel and renewable diesel, both of which utilize fats, oils, and greases as feedstocks, qualify for the generation of biomass-based diesel RINs under the advanced biofuel feedstock requirements of the RFS.

oils, and waste supplies, which truly reflect the strength of the country's grain, oilseed, livestock, biofuels, and recycling industries. Increased demand for these "by-product" commodities adds value across the supply chain and leads to higher levels of production of protein and carbohydrate commodities for food and feed, to the ultimate benefit of consumers. The impact of increased market value on supply is best demonstrated by the development of new markets for ICO, brown grease and used cooking oil (UCO or "yellow grease"). Increased recovery of ICO by dry mill corn ethanol plants is a direct response to higher market prices for a commodity thought to have little or no value. Similarly, development of the market for UCO also represents a reaction to economic signals. With the development of the biodiesel industry and new technologies for processing UCO into quality fuel, the market price for UCO increased dramatically, offering a source of revenue for restaurants rather than requiring a cost for disposal. Rapid development of UCO also led to greater recovery and reuse of trap grease or brown grease, which significantly alleviated what is a significant cost for municipal water systems.

The objective of this study is to estimate and project the production and availability of FOG feedstocks for biodiesel production. The results of this study indicate an ample availability of these RFS-approved alternative feedstocks to supply the growing biodiesel industry.

Introduction

Biodiesel is produced from a wide range of potential feedstocks including soybean oil, canola oil, distillers corn oil, animal fats and tallow, and recycled cooking oils and grease. Energy Information Administration (EIA) statistics indicate that nearly 7.9 billion pounds of fats and oils were used to produce 1.05 billion gallons of biodiesel in 2012.[3] By comparison, the U.S. used nearly 2 billion pounds of feedstocks to produce 250 million gallons of biodiesel in 2006, the year before the RFS was expanded. In 2006, soybean oil accounted for about 90 percent of biodiesel feedstocks. As shown in Table 1, vegetable oils, notably soybean and canola oil, remain the predominant biodiesel feedstocks,

[3] Data on biodiesel production published by EIA do not match that published by EPA on which RIN credits are calculated for RFS2 compliance. In this study we have use the higher EPA production levels and calculated feedstock use using the EIA shares. U.S. EPA RFS2 EMTS Informational Data. http://www.epa.gov/otaq/fuels/refsata/2012.htm. U.S. Energy Information Administration, Form EIA-22M "Monthly Biodiesel Production Survey"; EIA Monthly Biodiesel Production Report. http://www.eia.gov/biofuels/production accessed May 27, 2013.

accounting for 55 percent and 10.8 percent of feedstocks, respectively. Soybean and canola oil will continue to grow as biodiesel feedstocks as a result of improvements in yields reflecting better genetics and agronomic practices such as double cropping and rotations. Having a valuable energy market for these oils means that more protein and carbohydrates will be produced thereby incentivizing increased food production and helping control food costs.

Table 1
Feedstock Inputs for Biodiesel Production
(Million Pounds)

	2011	Share	2012	Share
Soybean Oil	4,494	57.0%	4,377	55.2%
Canola Oil	915	11.6%	856	10.8%
Yellow Grease	512	6.5%	666	8.4%
Distillers Corn Oil	331	4.2%	618	7.8%
White grease & other animal fats	670	8.5%	500	6.3%
Tallow	465	5.9%	412	5.2%
Other Recycled Grease	213	2.7%	309	3.9%
Poultry Fat	260	3.3%	182	2.3%
Other Feedstocks	32	0.4%	0	0.0%
Total Feedstocks	7,884	100.0 %	7,929	100.0 %
B100 Production (Mil gal)	1,047		1,053	
Avg Yield (lb/gal)	7.53		7.53	

Source: EIA Monthly Biodiesel Production Report, Table 3
EPA RFS2 EMTS Informational Data 2012

Animal fats (tallow, lard, white grease and other animal fats, and poultry fat) together represented 13.8 percent of biodiesel feedstocks, while yellow grease (UCO) and inedible corn oil accounted for 8.4 percent and 7.8 percent of inputs, respectively. Notably, alternative feedstocks increased from 31.4 percent of total feedstocks in 2011 to 34 percent in 2012. Preliminary data for the first several months of 2013 indicates that the share of biodiesel feedstocks other than soybean and canola oil increased to more than 38 percent.

Defining Animal Fats, Waste Greases and Inedible Plant Oils

Animal fats are by-products of livestock and poultry slaughter and meat production. The principal animal fats include:

- Edible/technical tallow typically is produced by rendering plants operated in conjunction with meat packing plants under USDA, Food Safety and Inspection Services (USDA/FSIS) inspection and processing standards.
- Inedible tallow mainly comes from rendering plants (operated by independent renderers or as part of integrated rendering operations) or beef slaughter houses and is essentially non-edible tallow produced by rendering beef offal. It is used as livestock and poultry feed, soap, for the production of fatty-acids, and as a biodiesel feedstock.[4]
- Lard is rendered pork fat.
- Choice White Grease is essentially non-edible lard produced by rendering pork offal.
- Poultry Fat is a by-product of poultry processing and rendering.

Waste greases and inedible plant oils are recycled cooking oil and recovered greases and byproduct oils such as distillers corn oil. The primary categories include:

- Yellow grease (UCO) is primarily derived from used cooking and frying oil from the restaurant and food service industry. Historically, the term yellow grease also has been used to describe lower-quality grades of animal fat that may have included dead stock. UCO is a historically underreported supply category. As biodiesel developed value for this waste grease, more UCO has been collected (but not reported to the U.S. Census), and less has ended up as a trap grease in restaurants.
- Brown, or trap, grease is a mixture of vegetable oil, animal fat, and other grease found in grease interceptors, typically from restaurants and other food-handling operations, and is collected by water treatment plants. Brown grease has a higher level of contamination compared to yellow grease, and cannot be used for animal feed or as fertilizer. While yellow grease is relatively consistent, brown grease varies in glycerin and fatty acid content, and has

[4] http://www.epa.gov/ttn/chief/ap42/ch09/final/c9s05-3.pdf

a much higher water content, all of which require additional processing prior to refining.[5]

- Inedible plant oils consist primarily of distillers corn oil or inedible corn oil (ICO) recovered by the dry mill corn ethanol industry. This category also would include oil recovered from other grains such as sorghum, wheat and barley. Ethanol producers have begun to extract non-food grade corn oil from Distillers dried grains with solubles (DDGS) for use as a biodiesel feedstock. This oil is of lower quality than corn oil produced for the food market but is an excellent biodiesel feedstock.

Waste Grease and Animal Fats Production

Data regarding the production and supply of rendered animal fats and waste grease and oils is often difficult to obtain. The U.S. Department of Commerce collected fats and oils production and use data and published the results monthly in the Current Industrial Reports (CIR) M311k series. The Census M311K series tracked production and stocks of edible and inedible tallow, lard, yellow grease, poultry fat, and "other grease". Unfortunately the CIR program was discontinued in August 2011 and no U.S. government agency currently tracks production of these products.

Other than the Census production data, several attempts have been made to estimate the production of these feedstocks with varying results.

- A profile of the North American Rendering Industry prepared for the National Renders Association (NRA) by Informa Economics in 2011 provided an estimate of rendered fats and greases production by type for 2010 based on a survey of NRA members.[6] Many UCO collectors are not members of the NRA and would not have been included in the Informa survey. Further, many of these UCO collection firms are relatively new companies that may not have been aware of the requirement to report production volumes to the U.S. Census.
- A market report prepared by NRA in March 2013 expands on the Informa study by estimating production and exports of rendered products – including animal fats and waste grease –

[5] S. Du, F. Poretti, I. Noshadi, R. Parnas, and G.M. Bollas. "100% Conversion of Waste Brown Grease to Biodiesel and Syngas As Valuable Products for Heat and Power Cogeneration." Conference Proceedings 2012 Annual Meeting, American Institute of Chemical Engineers.
[6] Informa Economics. "A Profile of the North American Rendering Industry". March 2011

through 2012.[7] Discussions with the study author indicated that the production estimates were prepared by correlating animal fats production to livestock (cattle, hog, and poultry) slaughter and assuming the same relative shares of fats and greases production provided by the Informa survey of NRA members.

Informa versus Census

Table 2 compares the production estimates reported by Census and Informa for 2010. While the estimates of total production of rendered fats and greases are relatively close, there are significant differences between individual categories. Specifically, the estimates provided by the Informa survey of NRA members report significantly more tallow and yellow grease than is reported by Census and significantly less poultry fat and lard. The Informa study differentiates choice white grease from the other grease category while Census does not. Consequently, definitional issues appear to be the major reason for the large deviations in these two categories.

Table 2
Comparison of Census and Informa Estimates for
Rendered Fats and Greases: 2010

	M311K 2010 Thou lbs	Informa 2010 Thou lbs	Informa vs Census Pct
Inedible Tallow	3,299.0	3,659.9	10.9%
Edible Tallow	1,859.3	2,189.8	17.8%
Yellow Grease	1,403.6	1,915.4	36.5%
Choice White Grease	Not reported	1,127.2	n/a
Poultry Fat	1,417.5	1,025.8	-27.6%
Lard	312.1	135.3	-56.6%
Other Grease	1,319.4	127.0	-90.4%
Total	9,611.0	10,180.5	5.9%

The primary differences between the production estimates reported by Census in the M311K reports and the Informa study most likely reflect differences in the data reported by NRA member survey participants.

[7] Kent Swisher. "Market Report - US Rendering: A $10 Billion Industry". *Render Magazine*. April 2013.

- Informa indicates that the data underlying their estimates was "…collected from 96 rendering plants across the United States and Canada, including independent renderers ranging in size from single plant operations to the very largest firms operating many plants in several states."[8]

- The primary objective of the CIR program was to produce timely, accurate data on production and shipments of selected products and was used to satisfy economic policy needs and for market analysis, forecasting, and decision making in the private sector. "The CIR program uses a unified data collection, processing, and publication system. The U.S. Census Bureau updates the survey panels for most reports annually and reconciles the estimates to the results of the broader-based annual survey of manufactures and the economic census, manufacturing sector. The manufacturing sector provides a complete list of all producers of the products covered by the CIR program and serves as the primary source for CIR sampling. Where a small number of producers exist, CIR surveys cover all known producers of a product. However, when the number of producers is too large, cutoff and random sampling techniques are used. Surveys are continually reviewed and modified to provide the most up-to-date information on products produced. The CIR program includes a group of mandatory and voluntary surveys. Typically the monthly and quarterly surveys are conducted on a voluntary basis. Those companies that choose not to respond to the voluntary surveys are required to submit a mandatory annual counterpart corresponding to the more frequent survey."[9] CIR surveys for the fats and oils industry had been conducted since 1904 and were among the first conducted by the Census Bureau.

A review of the NRA membership list and product codes associated with individual members suggest that the Informa survey may over sample cattle and hog processors and renderers and under sample poultry processors relative to the Census Bureau M311K survey.[10] This would explain the larger estimates for tallow and smaller estimates of poultry fat production. The Informa study also estimates choice white grease and includes an estimate of other grease which they describe as including "… fish oil, trap grease, brown grease and other specific items identified by individual renderers". The Census M311K series reports an "other grease" category (NAICS product code 3116132141) which

[8] Informa p2.
[9] http://www.census.gov/manufacturing/cir/how_the_data_are_collected/index.html
[10] http://www.nationalrenderers.org/about/directory/

includes inedible lard (choice white grease) and other greases including brown grease. If the choice white grease and other greases categories are aggregated the Informa estimate of production is only 4.9 percent below the Census estimate of 1.32 billion pounds of "other grease."

The other significant difference between the Informa and Census estimates is yellow grease. The Informa survey specifically asked NRA members to report approximate production of "Yellow Grease (predominately restaurant grease)". As Informa points out, rendering facilities owned by meat packers are more likely to produce products that are species-specific such as edible tallow, choice white grease, and lard. Independent renderers typically collect raw materials from a wider range of sources and are more likely to produce inedible tallow. Moreover, "restaurant grease is only collected by independent renderers, so they are the sole producers of yellow grease".[11] Informa included some independent renderers in their survey and indicated that data for independent renderers was estimated based on industry discussions and the allocation of volumes unaccounted for by other means. Our discussions with industry participants indicated that several waste grease collectors were reluctant to participate in the Census surveys or were new firms and were unaware of the requirement to participate, thereby leading to underreporting of yellow and other grease production. This may explain the difference between the Informa and Census estimates noted above.

NRA Market Study

As indicated above, NRA published a market analysis in March 2013 that combined the Informa and Census results to project production and exports of rendered products – including animal fats and waste grease – to 2012. Table 3 compares the Census M311K production estimates to those of NRA and Table 4 compares NRA projections for 2011 to annualized Census estimates for 2011 and provides the NRA projection for 2012.

Table 3
Comparison of Census and NRA Estimates for
Rendered Fats and Greases: 2010

	M311K	NRA	Diff NRA

[11] Informa, p.39

	2010 Thou lbs	2010 Thou lbs	vs Census Pct
Inedible Tallow	3,299.0	3,331.6	1.0%
Edible Tallow	1,859.3	1,824.5	-1.9%
Choice White Grease	1,319.4*	1,127.2	-14.6%
Lard	312.1	135.4	-56.6%
Yellow Grease	1,403.6	1,915.4	36.5%
Poultry Fat	1,417.6	1,038.6	-26.7%
Total	9,611.0	9,372.6	-2.5%

* Other grease category in M311K report

The NRA estimates for rendered fats and waste grease production for 2010 are closer to the Census estimates than are the Informa results. The largest differences remain for yellow grease and poultry fat. The NRA estimates were prepared by applying the historic relationships between livestock production reported by USDA/NASS and rendered product production reported in the Census M311K series (prior to 2010). [12]

Table 4
Comparison of Census and NRA Estimates for
Rendered Fats and Greases: 2011

	M311K 2011 Thou lbs	NRA 2011 Thou lbs	Diff NRA vs Census Pct	NRA 2012 Thou lbs	NRA Change 2012-2011
Inedible Tallow	3,250.1	3,277.8	0.9%	3,203.7	-2.3%
Edible Tallow	1,980.0	1,954.8	-1.3%	1,790.1	-8.4%
Choice White Grease	1,321.6*	1,142.9	-13.5%	1,169.1	2.3%
Lard	228.0	137.1	-39.9%	140.4	2.4%
Yellow Grease	1,339.5	1,998.2	49.2%	1,951.1	-2.4%
Poultry Fat	1,412.4	1,047.6	-25.8%	1,046.7	-0.1%
Total	9,531.7	9,558.5	0.3%	9,301.2	-2.7%

* Other grease category in M311K report

A comparison of NRA's estimate for 2011 to annualized data for seven months of 2011 suggests that in the aggregate the NRA estimates, and consequently projections for 2012, do a good job of replicating the total of rendered fats and waste grease production reported by the Census Bureau.

<u>Yellow Grease</u>

[12] Swisher, NRA, p 11

As noted above, the estimates of yellow grease production reported by Informa and NRA are substantially higher than those reported by the Census Bureau. This is significant because yellow grease is becoming an increasingly important biodiesel feedstock. Informa based its estimate of yellow grease production on discussions with independent renderers. NRA derived yellow grease production by using the relationships between yellow grease output in the Informa study and cooking oil consumption as reported by USDA. The biggest issue with this is that the USDA food consumption series for cooking oil is an aggregate of consumer at-home use and restaurant (food-away from home) use.[13] Consequently using this series combined with the overestimate of yellow grease production by Informa is likely "carried over" into the NRA estimates.

The Census yellow grease production data are the most comprehensive available. Yellow grease was first reported as a separate category in 1991 and reported production averaged 2,688 million pounds until 2003 when the Other Grease category was added.

The most frequently cited source for yellow and brown grease supply remains a 1998 study of waste grease in urban areas prepared for NREL.[14] This study collected and analyzed data on yellow grease collected from restaurants and grease trap wastes (brown grease) from restaurants in 30 randomly selected metropolitan areas in the United States. Study results indicated that the amount of yellow grease feedstock collected from restaurants ranged from about 3 to 21 pounds/year/person. A statistical analysis of the relationship between the number of restaurants and the number of people in a metropolitan area suggested production of 8.87 pounds of yellow grease per capita.

Applying this per capita estimate to total U.S. population for 2010 suggests total yellow grease production of 2,748 million pounds. Interestingly, the sum of yellow and other grease reported by Census for 2010 was 2,723 million pounds, a difference of about one percent. Further confirmation of these results are provided by dividing yellow and other grease production by U.S. population. Over the last decade per capita yellow grease production as reported by the Census Bureau averaged 9.1 pounds/person, a result consistent with NREL findings. However, if we assume that there is a downward bias in the Census estimates caused by underreporting and use the difference between the Informa and Census estimates as a guide, the estimated production of yellow grease in 2010 would

[13] http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx. Fats and Oils.
[14] G. Wiltsee. Urban Waste Grease Resource Assessment" NREL/SR-570-26141. November 1998.

total about 3.4 billion pounds, or 11.1 pounds per capita. This estimate is higher than that predicted in the NREL study but is well within the range suggested by the data. It is important to note that these estimates relate to production and not collection and therefore indicate potential supply. The waste grease industry is still growing and has not reached maturity. We expect that the actual supply of waste grease will expand over time.

Brown Grease

Brown grease is a mixture of vegetable oil, animal fat, and other grease found in grease interceptors, typically from restaurants and other food-handling operations, and is collected by water treatment plants. As indicated earlier Brown grease has a higher level of contamination compared to yellow grease, and cannot be used as animal feed. Brown grease varies in glycerin and fatty acid content, and has a much higher water content than yellow grease. Published reports indicate that brown grease typically has a water content in excess of 20 percent and a Free Fatty Acid (FFA) content of 15 to 50 percent of raw material.[15] By comparison the FFA content of yellow grease typically ranges between 4 percent and 15 percent.[16]

No reliable source of data on brown grease production has been identified, and published estimates vary wildly. The 1998 NREL study indicated per capita production of 13.37 pounds. NREL comments that this estimate likely includes water and is "probably a little high."[17] Anecdotal reports seem to support production at these levels. For example, a 2009 article in the San Francisco Chronicle reported that "... about 10 million gallons of brown grease are produced in San Francisco every year, most of it safely collected and treated in the city's sewer system like any other waste material".[18] When expressed on a per capita basis this amounts to 11.7 pounds.

National level brown grease production consistent with these per capita levels is improbable, even when adjusted for water content, and is not supported by any available data source. A more realistic

[15] Christina Borgese and Marc Privitera. "Quick and Dirty Feedstock Characterization". *Biodiesel Magazine*. July 18, 2011.
[16] K. Shaine Tyson. "Brown Grease Feedstocks for Biodiesel" NREL. June, 2002 and Robert Wallace and John Pierson. "Researching Brown Grease as a New Opportunity". *Render Magazine*. August 2010.
[17] Tyson, 2002
[18] Erin Allday. "S.F. to convert gookiest cooking grease to fuel". San Francisco Chronicle. February 5, 2009. http://www.sfgate.com/green/article/S-F-to-convert-gookiest-cooking-grease-to-fuel-3252190.php#ixzz2Upfyvinz

estimate may be the two pounds per capita production estimate reported by Burgess.[19] This implies an annual potential brown grease production of about 600 million pounds.[20] Collection also is an issue with brown grease and the availability of this feedstock is expected to increase over time as collection expands and improves.

Distillers Corn Oil or Inedible Corn Oil (ICO)

ICO is non-food grade oil extracted from Distillers dried grains with solubles (DDGS) by the corn ethanol industry. This oil is of lower quality than that extracted from the corn kernel for the food market. ICO is darker in color, viscous and high in free fatty acid content, all of which are indicators of oil degradation making it unsuitable for human consumption.[21] Additionally ICO also has higher levels of gum, water, phospholipids and nonlipid materials than food grade corn oil.[22]

No one tracks the production of ICO on an industry-wide basis. The Biofuels Benchmarking™ service of Christianson & Associates, PLLP provides perhaps the most comprehensive analysis of ICO produced by the dry mill corn ethanol industry. This survey has been conducted quarterly since 2008 and includes reports by 85 participating corn dry mill ethanol plants (about half of operating corn dry mill ethanol plants) that include recovery of corn oil and average corn oil yields. The Christianson Biofuels Benchmark survey reports that the percentage of dry mill plants recovering distiller's corn oil has increased from 45 percent in 2009 to about 75 percent today. The Christianson survey also reports that average ICO yields have increased from 0.3 pounds per bushel in 2008 to more than 0.5 pounds currently, with the top 25 percent of dry mills reporting ICO yields of nearly 0.8 pounds per bushel.[23]

These data are corroborated by information provided by Geoff Cooper, Vice President of Research at the Renewable Fuels Association who estimates that 70 to 75 percent of all dry mill corn ethanol

[19] Milton K. Burgess, "What to do with Brown Grease?" *Plumbing Systems & Design*. April 2010. P 25
[20] Conversation with Emily Landsburg, CEO BlackGold Biofuels.
[21] Sandra Majoni. "Oil recovery from condensed corn distillers solubles". PhD Dissertation, Iowa State University. 2009. http://udini.proquest.com/view/oil-recovery-from-condensed-corn-pqid:1868390891/
[22] Conversation with Dr. Michael Haas, Research Scientist, Sustainable Biofuels and Co-Products. USDA/ARS/ERRC
[23] Data provided by John O. Christianson, Principal, Christianson & Associates, PLLP June 27, 2013

plants currently recover ICO and that ICO yields average 0.6 pounds per bushel of corn.[24] According to the Renewable Fuels Association the nation's ethanol industry produced 13.3 billion gallons of ethanol in 211 plants in 2012, up from 9.3 billion gallons from 139 plants in 2008. Further, RFA estimates that dry mill corn ethanol plants account for at least 90 percent of production. According to USDA the amount of corn used to produce ethanol has increased from 3 billion bushels in the 2007 marketing year to nearly 4.7 billion bushels in 2012.[25] Using the yield and adoption rate data provided by Christianson & Associates, ICO production has grown from an estimated 520 million pounds in 2009 to nearly 1.7 billion pounds in 2012. Considering that EIA reported that 571 million pounds of corn oil was used to produce biodiesel in 2012, this equates to about a third of estimated ICO production. This is consistent with industry reports that in 2012 about 40 percent of ICO was used for biodiesel with the remaining 60 percent used in the animal feed and industrial markets.

Future growth in ICO production is expected to come from a combination of an increasing share of plants that recover ICO and increased ICO yields. The RFS requires 15 billion gallons of corn ethanol in 2015. This implies an upper limit on growth for dry mill ethanol production of 12.5 percent between 2012 and 2015. However, the improved revenue realized by recovering distiller's corn oil and growth in the biodiesel market is expected to prompt a vast majority of dry mill ethanol plants to recover this byproduct. As a result of advances in technology directed at recovering higher percentages of distiller's corn oil from the post-fermentation ethanol stream, the average industry-wide yield is expected to increase from current levels of about 0.6 pounds per bushel to about 1.4 pounds per bushel, or about two thirds of available oil, by 2022.[26] The new oil recovery technologies include improved centrifugal separation processes, improved enzymatic conversion processes, and increased use of solvent recovery.[27] As shown in Figure 1 and Table 5, ICO production is projected to exceed 6.7 billion pounds by 2022.

[24] Email from Geoff Cooper, Vice President, Research, Renewable Fuels Association.
[25] USDA ERS Feedgrains Database. http://www.ers.usda.gov/data-products/feed-grains-database.aspx. Accessed July 14, 2013. USDA reports corn use on a marketing year (September – August) basis. The 2007 marketing year begins in September 2007 and ends in August 2008.
[26] Corn has oil content of 3.8 percent so a 56 pound bushel of corn contains 2.09 pounds of oil.
[27] Ongoing research on enzymatic recovery of corn oil at the USDA ARS Eastern Regional Research Center in Wyndmoor, PA is showing consistent recovery of 70 percent of available oil, which equates to 1.46 lb/bu.

Figure 1
Distillers Corn Oil Production

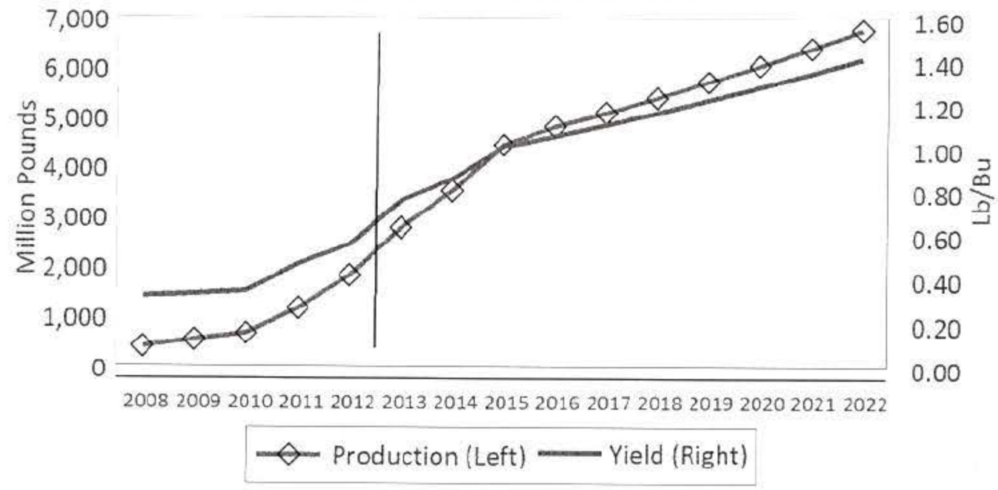


Table 5
Estimated Distillers Corn Oil Production: 2008-2022

	Conventional Ethanol (Mil Gal)	Ethanol From Corn (Mil Gal)	Corn Dry Mill (Mil Gal)	% of Industry Adopting Oil Recovery (Pct)	Bushel Equivalent (Mil Bu)	ICO Recovery Rate (Lb./bu)	Inedible Corn Oil Production (Mil lb)
2008	9,309	9,123	8,210	40%	1,194	0.32	376
2009	10,938	10,719	9,647	45%	1,579	0.33	513
2010	13,298	13,153	11,838	44%	1,894	0.34	640
2011	13,929	13,764	12,388	55%	2,478	0.46	1,144
2012	13,300	13,275	11,947	75%	3,258	0.55	1,792
2013	14,177	14,052	12,647	85%	3,909	0.70	2,736
2014	14,791	14,366	12,929	87%	4,090	0.85	3,477
2015	15,558	14,983	13,485	90%	4,413	1.00	4,413
2016	16,162	15,387	13,848	91%	4,557	1.05	4,785
2017	16,660	15,435	13,891	91%	4,597	1.10	5,068
2018	17,257	15,482	13,934	92%	4,636	1.16	5,367
2019	17,855	15,530	13,977	92%	4,676	1.22	5,684
2020	18,452	15,577	14,019	93%	4,716	1.28	6,018
2021	19,050	15,625	14,062	93%	4,756	1.34	6,373
2022	19,647	15,672	14,105	94%	4,796	1.41	6,748

Distillers corn oil recovery and yield data for 2008-2012 from Christianson & Associates, PLLP

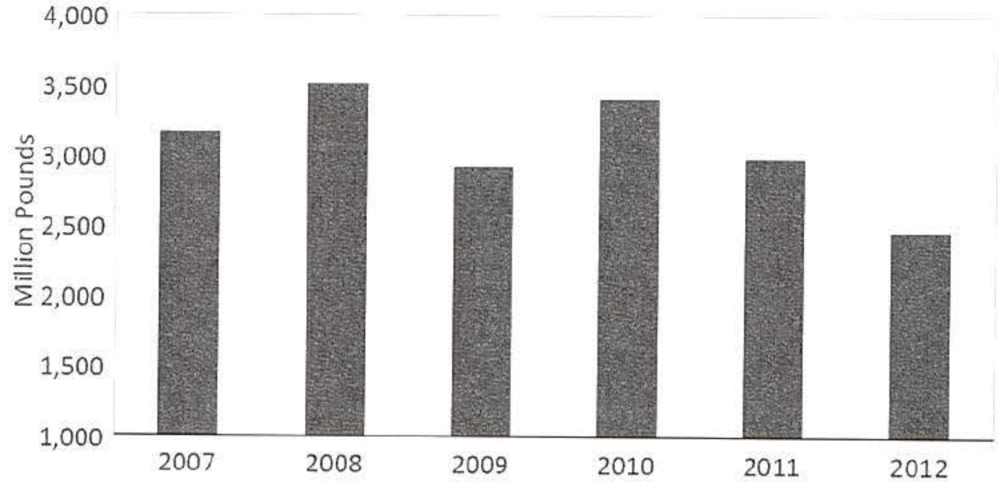
The estimate of ICO discussed above does not take into consideration the potential availability of oil from other grains such as sorghum that have been approved as advanced biofuel feedstocks under RFS rules. As discussed earlier, corn starch-ethanol requirements are set at 15 billion gallons in 2015. The RFS proscribes that the remaining 21 billion gallons of biofuels consist of cellulosic biofuels, biodiesel, and biofuels from undifferentiated advanced biofuel feedstocks. Grain sorghum and cover crop wheat are among the currently approved advanced biofuel feedstocks. EPA has determined that ethanol produced from barley meets the GHG emission reduction threshold for conventional renewable fuels and that dry milled ethanol facilities that use certain technologies could meet threshold for advanced biofuels required by EISA. As the final step in the approval process EPA has requested public comment on barley.[28] Grain sorghum contains about 3.4 percent oil and barley contains 1.8 percent oil providing maximum available oil of 1.9 and 0.9 pounds per bushel, respectively. We have not estimated the potential use of sorghum or barley as advanced biofuel feedstocks or the potential oil that may be recovered and made available for use as a biodiesel feedstock.

Waste Grease and Animal Fats Trade

While the U.S. currently is a net exporter of animal fats and waste grease, the share of production exported has declined from about a third to about 22 percent. Trade data extracted from the U.S. International Trade Commission Interactive trade database[29] indicates that the U.S. exported 2,455 million pounds of waste grease and animal fats in 2012 and imported 213 million pounds. As shown in Figure 2, U.S. exports of animal fats and waste grease have declined significantly since implementation of RFS2 in 2007. The upturn in 2010 exports is directly attributable to the decline in biodiesel production following expiration of the biodiesel tax credit at the end of 2009, which was reinstated retroactively in December of 2010. As biodiesel demand continues to grow, we expect this trend to continue and accelerate thereby increasing domestic availability of these feedstocks. This is a consequence of the RFS incentivizing the value-added process of finishing these feedstocks into refined products here at home. As a result of the program, the U.S. captures more value domestically, adding to overall GDP.

[28] "EPA Issues Notice of Data Availability Concerning Renewable Fuels Produced from Barley Under the RFS Program" EPA-420-F-13-039. July 2013
[29] http://dataweb.usitc.gov/scripts/user_set.asp

Figure 2
U.S. Exports of Animal Fats and Waste Greases



Source: USITC. Does not include ICO

Table 6
U.S. Exports of Waste Grease and Animal Fats
2008-2012

	2008 (Mil lb)	2009 (Mil lb)	2010 (Mil lb)	2011 (Mil lb)	2012 (Mil lb)
Tallow	2,222.8	1,763.3	1,906.6	1,449.4	1,238.1
Animal/Vegetable Blend	482.1	539.7	617.8	606.1	788.9
Yellow Grease	527.6	436.0	592.4	629.1	221.3
Other Grease*	188.0	86.2	205.8	207.6	149.1
Lard	82.1	84.3	71.5	78.8	54.8
Choice White Grease	2.6	3.9	8.1	5.7	3.1
Total	3,505.1	2,913.3	3,402.2	2,976.7	2,455.3

*Includes Poultry fat

Exports are dominated by inedible tallow, which accounted for 56 percent of exports. The next largest categories are animal and vegetable blends and yellow grease at 20 percent and 16 percent of total exports, respectively. Mexico is by far the largest U.S. market for waste grease and animal fats exports, accounting for more than 43 percent of total exports over the past five years.

Canadian Waste Grease and Animal Fats Production

We were unable to locate and identify data on Canadian waste grease and animal fats published by either the Canadian statistical service or private firms. However Statistics Canada does publish livestock slaughter and meat and poultry production data. The structure of the Canadian beef, swine and poultry industry is not dissimilar from that found in the U.S. aside from scale.[30] If we assume that the production of tallow and lard per slaughtered head in Canada approximates the experience in the U.S., we estimate that edible tallow production in Canada amounted to 173 million pounds (78.4 thousand metric tonnes (mt)) and inedible tallow production totaled 320 million pounds (145 thousand mt) in 2012. Similarly, lard/choice white grease production is estimated at 58.7 million pounds (26.6 thousand mt) in 2012.

A double check on this is provided by comparing animal fat production presented in a 2006 Canadian biodiesel economic impact analysis (Stiefelmeyer).[31] This study cited earlier studies that estimated Canadian animal fats production of 251.6 thousand mt (555 million pounds) of tallow in 2002 and 389.2 thousand mt (858 million pounds) in 2006. Using the approach described on page 15 above we would estimate tallow production of 267 thousand mt in 2002 and 340 thousand mt in 2006. The similarities of the reported and calculated 2002 and 2006 data suggest that the estimation method employed is appropriate.

The Stiefelmeyer study also estimates waste grease availability in Canada and points out that because brown grease has higher levels of free fatty acids and other impurities that make it more difficult to process than yellow grease, brown grease is unlikely to be used as a biofuel feedstock in Canada.[32] Having said this, it is important to note that the major Canadian cities also are struggling with how to deal with waste grease and oil in water treatment. As a consequence, brown grease may

[30] http://www.canadabeef.ca/ca/en/rt/industry/Trade/default.aspx. http://www.canadapork.com/en/industry-information/hog-production-in-canada
[31] Kate Stiefelmeyer, Al Mussell, Terri-lyn Moore and Dake Liu. "The Economic Impact of Canadian Biodiesel Production on Canadian Grains, Oilseeds and Livestock Producers Final Report". George Morris Centre. May 16, 2006. Pp. 45-46.
[32] Steifelmeyer, p 46.

become a more prominent potential feedstock in the future.

Stiefelmeyer used the same procedure as did Wiltsee in the 1998 NREL study to estimate Yellow grease production. Specifically they determined a per capita production rate and applied it to the Canadian population. Using the same approach provides an estimate of 307 million pounds (140 thousand mt) of yellow grease in 2012 production in Canada.

A recent USDA report indicates that domestic production of biodiesel in Canada was forecast to reach 284 million liters (75 million gallons) in 2012, a nearly 80 percent increase over 2011 levels.[33] A Canadian federal mandate for biodiesel use, extension of a government program to help increase investment in the biodiesel industry, and the completion of four new biodiesel production facilities is expected to help increase production levels of biodiesel to 538 million liters (142 million gallons) in 2013, and surpass the Canadian federal requirement by 2014. USDA further reports that the share of biodiesel production from tallow is expected to fall from 2011 levels of 60 percent to 38 percent due to new biodiesel plants using other feedstocks, notably canola oil. Canada biodiesel supply will increasingly come from canola biodiesel producers. As a result Canadian animal fat and waste greases and Canadian biodiesel produced from those feedstocks will increasingly be available for export to the U.S.

The key assumptions and estimates for Canadian animal fats and waste grease production in 2012 are presented in Table 7.

[33] "Canada Biofuels Annual 2012" USDA Foreign Agricultural Service. GAIN Report CA12024. June 29, 2012

Table 7
Canada: Estimated Animal Fats and Waste Grease Production

Assumptions	**2012**	
Cattle and Calf Slaughter (Thou hd)	3,208.0	
Hog Slaughter (Thou hd)	21,500	
Chicken Production (Thou mt)	1,037.6	
Population (Mil)	34.9	
Production	**Thou mt**	**Mil lbs**
Edible Tallow	173.0	381.4
Inedible Tallow	319.5	704.4
Lard/Choice White Grease	58.70	129.4
Poultry Fat	91.7	202.1
Yellow Grease	307.0	676.7
Total	949.8	2,094.0

Source for Assumptions: Statistics Canada

Assuming that half of these feedstocks were used to produce biodiesel they would support production of 140 million gallons (nearly 530 million liters) of biodiesel, almost precisely the level projected by USDA for 2013.

Animal Fats and Waste Grease Forecast

United States

A major objective of this study is to predict the production of animal fats and waste grease in North America through 2022, currently the last year of required increases in the RFS. This was accomplished by estimating relatively simple Ordinary Least Squares regression equations for each category of animal fats and waste grease using historical Census data extracted from the M311K annual summary reports[34], cattle and hog slaughter and broiler production extracted from USDA/NASS online databases[35]; and economic data (real personal consumption expenditures and real per capita disposable income) from the Bureau of Economic Analysis.[36]

[34] Monthly and annual production data for the period 2000 through 2010 were provided by Census upon request.
[35] http://quickstats.nass.usda.gov/
[36] http://www.bea.gov/iTable/index_nipa.cfm

Estimating the relationship between tallow and lard and cattle and hog slaughter makes intuitive sense since these are products and by-products of the livestock slaughter and meat production industry. Similarly, poultry fat production is directly dependent on poultry (in this case broiler) production. The relationships were statistically tested for stability and equations were estimated both in monthly and annual frequencies. The data used for the analysis is presented in Appendix I.

Yellow and other grease are not dependent on animal slaughter but are closely related to food consumption. Presumably as food consumption increases so does the production of by-products such as waste cooking oil (yellow grease) and trap grease. As indicated earlier, the most frequently cited analysis of yellow and brown grease production in the U.S. (Wiltsee) estimated the relationship between grease production and population and the restaurant numbers and arrived at ranges of per capita production. We tested a number of specifications but determined that the "best fit" that also made economic sense was between the sum of yellow grease and other grease as detailed in the Census reports and real personal consumption expenditures for food. As pointed out earlier, the results of this analysis are consistent with Wiltsee's results.

In order to produce a forecast using these equations we utilized projections of cattle and hog slaughter and chicken production from the FAPRI March 2013 U.S. Agricultural Baseline Forecast.[37] Projections for real personal disposable income and real personal consumer expenditures were extracted from the 2013 USDA Long-Term Baseline Forecast.[38]

Total production of animal fats and yellow grease in the U.S. is projected to increase from an estimated 12.1 billion pounds in 2011 to 19.4 billion pounds by 2022 with the most significant growth occurring in poultry fat, yellow and brown grease, and distillers corn oil. Increased consumption of broilers and improved expenditures on food anticipated as the economy slowly recovers are the primary drivers for the growth in animal fat availability. Tallow production is expected to remain sluggish until the cattle industry recovers from recent reductions in herds and slaughter.

As indicated earlier, demand for biodiesel accounted for about a third of the production of animal fats,

[37] "U.S. Baseline Briefing Book: Projections for Agricultural and Biofuel Markets. Food and Agricultural Policy Research Institute". University of Missouri. March 2013. FAPRI-MU Report #01-13. Available online at: http://www.fapri.missouri.edu/outreach/publications/2013/FAPRI_MU_Report_01_13.pdf

[38] USDA Agricultural Projections Report (OCE-2013-1). http://www.ers.usda.gov/topics/farm-economy/agricultural-baseline-projections.aspx

waste grease and ICO in 2012. Currently other major uses for these products are as ingredients in livestock, poultry and aquaculture and companion animal feeds; industrial uses; and the manufacture of soaps and personal care products. Growth in these non-biodiesel markets for animal fats and waste greases and oils is expected to be in line with population growth over the next decade while the availability of ICO expands. We expect that there will be adequate supplies of animal fats, waste grease, and oils to meet the needs of these market segments. However, they will lose market share to the biodiesel industry whose growth will be supported by increased supplies of ICO and displaced exports. At more than 6 billion pounds by 2022, the increase in the ICO production is 10-fold greater than the sum of the other components change in supply.

Reflecting this, we have assumed that the proportion of animal fats, waste greases and oils, and distillers corn oil for biodiesel production increases from about 30 percent of the biodiesel feedstock stream today to nearly 60 percent by 2022. Consequently, these feedstocks alone would support nearly 1.5 billion gallons of biodiesel production by the terminal year of the RFS. The projected growth in biodiesel production supported by animal fats, waste greases and oils, and inedible corn oil is shown Figure 3 and the key assumptions and forecasts for animal fats and waste grease production through 2022 for the U.S. are shown in Table 8.

Figure 3
Biodiesel Produced from Animal Fats, Waste Greases & Oils

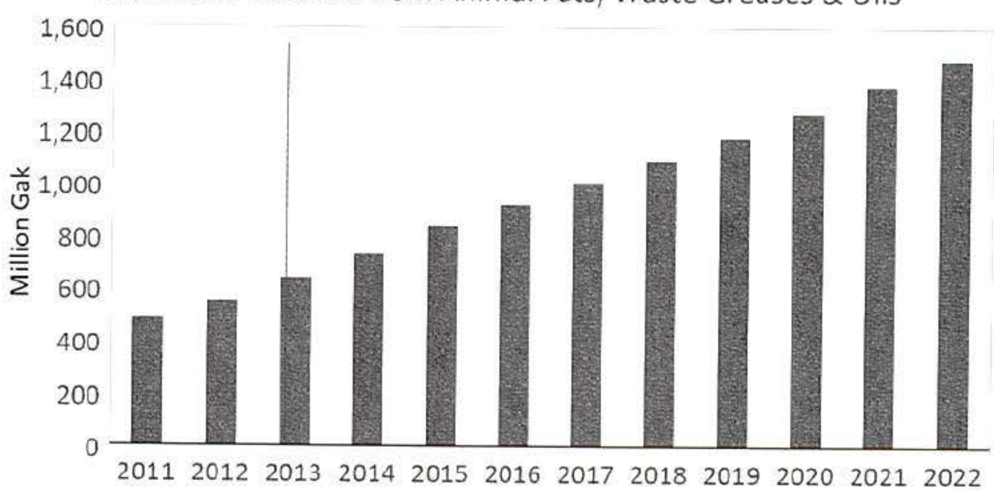


Table 8
U.S. Animal Fats and Waste Grease Forecasts: 2011 – 2022

ASSUMPTIONS	Cattle/Calf Slaughter (Mil Hd)	Hog Slaughter (Mil Hd)	Broiler Production (Mil Lbs)	Per Cap Disposable Income (Mil 2005$)	Personal Consumption Expenditures (Mil 2005$)	Food Spending (Mil 2005$)	Mid-Year Population (Million)
2011	35.1	107.5	36,803	$32,527	$9,429	$685	312.0
2012	34.0	109.8	36,544	$32,841	$9,603	$686	314.3
2013	32.3	110.3	36,502	$33,183	$9,838	$708	316.6
2014	32.0	110.7	37,578	$33,707	$10,121	$729	318.9
2015	32.0	112.0	38,589	$34,393	$10,374	$747	321.3
2016	32.2	114.2	39,411	$35,084	$10,633	$766	323.8
2017	32.7	116.1	40,012	$35,780	$10,899	$785	326.4
2018	33.1	116.7	40,535	$36,490	$11,172	$804	329.0
2019	33.4	117.1	41,092	$37,214	$11,451	$824	331.6
2020	33.2	117.9	41,685	$37,953	$11,737	$845	334.3
2021	33.0	119.3	42,297	$38,706	$12,031	$866	336.9
2022	32.7	120.6	42,951	$39,474	$12,331	$888	339.6

FORECAST	Edible Tallow (Mil lbs)	Inedible Tallow (Mil lbs)	Lard (Mil lbs)	Poultry Fat (Mil lbs)	Yellow Grease (Mil lbs)	Brown Grease (Mil lbs)	Distillers Corn Oil (Mil lbs)	Total (Mil lbs)
2011	1,980	3,250	228	1,412	3,459	624	1,144	12,098
2012	1,832	3,383	300	1,465	3,201	707	1,792	12,680
2013	1,810	3,359	301	1,459	3,244	792	2,736	13,702
2014	1,806	3,354	302	1,539	3,283	877	3,477	14,638
2015	1,805	3,354	306	1,600	3,317	964	4,413	15,759
2016	1,809	3,358	312	1,654	3,353	1,052	4785	16,323
2017	1,815	3,364	317	1,699	3,389	1,142	5,068	16,794
2018	1,820	3,370	319	1,742	3,426	1,234	5,367	17,277
2019	1,824	3,374	320	1,786	3,464	1,326	5,684	17,778
2020	1,822	3,372	322	1,833	3,503	1,421	6,018	18,291
2021	1,819	3,369	326	1,881	3,543	1,516	6373	18,826
2022	1,815	3,365	329	1,931	3,584	1,613	6,748	19,386

Canada

The forecast procedure for Canada was essentially the same as for the U.S. with the exception of the determination of key assumptions. Historical data for livestock slaughter and poultry production was taken from Statistics Canada databases.[39] However, since historical data for fats and grease production were not available we were unable to estimate supply equations.

As indicated earlier the structure and operation of the Canadian livestock and poultry industry is not dissimilar from the U.S. and is affected by many of the same forces. Consequently, in order to provide estimates and project Canadian production of animal fats and waste grease we assumed that Canadian animal fats and waste grease production would be determined in much the same way as is the case in the U.S. According to the Canadian Renewable Fuels Association, Canadian ethanol production is estimated at 500 million gallons. Compared to the U.S. where virtually all ethanol currently is made from corn, corn accounts for about two-thirds of Canadian ethanol production, with wheat making up most of the rest.[40] No information regarding ICO production in Canada is available. However if we apply the same ICO extraction penetration and yields as in the U.S., Canadian ICO production would total 52 million pounds, enough to support the production of 7 million gallons of biodiesel. Considering this relatively small volume and the predominance of canola as a biodiesel feedstock we have not included ICO production in the animal fats and waste grease projections for Canada.

In order to produce projections, we assumed that Canadian cattle and hog slaughter and chicken production would increase at the same rates as their U.S. counterparts through 2022. In the case of yellow grease we assumed the same per capita production as in the U.S. and applied this to projections of Canadian population. As seen in Table 9, we estimate that slightly more than 2 billion pounds of animal fats and waste grease were produced in Canada in 2011, increasing to more than 2.2 billion pounds by 2022.

[39] Statistics Canada, Agriculture. Livestock and aquaculture. Detailed tables from CANSIM available at http://www5.statcan.gc.ca/subject-sujet/result-resultat.action?pid=920&id=2553&lang=eng&type=ARRAY&pageNum=1&more=0
[40] http://www.greenfuels.org/en/industry-information/plants.aspx

Table 9
Canada Animal Fats and Waste Grease Forecasts: 2011 – 2012

ASSUMPTIONS	Cattle/Calf Slaughter (Mil Hd)	Hog Slaughter (Mil Hd)	Broiler Production (Mil mt)	Population (Million)
2011	3,390.9	21,189	1,026.9	34.5
2012	3,208.0	21,500	1,037.6	34.9
2013	3,054.1	21,588	1,036.4	35.3
2014	3,022.2	21,666	1,066.9	35.7
2015	3,018.4	21,925	1,095.6	36.0
2016	3,045.2	22,352	1,119.0	36.4
2017	3,084.0	22,734	1,136.0	36.8
2018	3,122.0	22,845	1,150.9	37.2
2019	3,151.8	22,927	1,166.7	37.7
2020	3,137.8	23,085	1,183.5	38.1
2021	3,114.7	23,351	1,200.9	38.5
2022	3,089.0	23,601	1,219.5	38.9

PRODUCTION FORECASTS	Edible Tallow (Mil lbs)	Inedible Tallow (Mil lbs)	Yellow & Other Grease (Mil lbs)	Lard (Mil lbs)	Poultry Fat (Mil lbs)	Total (Mil lbs)
2011	421.4	691.6	648.3	99.1	191.5	2,052.0
2012	381.4	704.4	676.7	129.4	202.1	2,094.0
2013	376.9	699.5	684.1	129.9	201.3	2,091.8
2014	376.0	698.4	691.7	130.4	212.4	2,108.9
2015	375.9	698.3	699.3	132.0	220.8	2,126.3
2016	376.7	699.2	707.0	134.5	228.2	2,145.6
2017	377.8	700.4	714.7	136.8	234.5	2,164.3
2018	378.9	701.6	722.6	137.5	240.3	2,181.0
2019	379.8	702.6	730.6	138.0	246.5	2,197.4
2020	379.4	702.1	738.6	138.9	252.9	2,212.0
2021	378.7	701.4	746.7	140.5	259.5	2,226.9
2022	378.0	700.6	754.9	142.0	266.5	2,242.0

Conclusion

The use of RFS-qualifying alternative FOG feedstocks for biodiesel production has increased significantly in recent years as a result of RFS and is expected to continue to increase significantly in response to expected continued growth in RFS requirements for the production of biomass-based diesel. Our analysis of FOG production indicates that FOG supply is projected to increase from an estimated 12.7 billion pounds in 2012 to more than 19 billion pounds by 2022. The most significant growth in FOG feedstocks for biodiesel production is expected in waste grease (both yellow and brown) and ICO due to increased recovery and improved yields resulting from new technology and/or displaced exports.

A major development in the supply of waste greases and oils has been increased recovery of ICO. Recovery of ICO currently adds 6 to 8 cents per gallon of revenue for a dry mill corn ethanol producer.[41] Penetration of ICO recovery technology is expected to increase from an estimated 75 percent of dry mills today to more than 90 percent by 2022. In addition, the development of new extraction technologies is projected to increase yields significantly by 2022. This combination is expected generate 6.7 billion pounds of ICO by 2022.

Canada produced an estimated 2.1 billion pounds of FOG in 2012. If even half of this output was used by Canadian biorefineries, it would fully meet projected biodiesel feedstock demand in Canada. However, the Canadian biodiesel industry is moving toward increased use of canola oil as a feedstock, reflecting concerns about cold flow properties of biodiesel in northern climates, and is targeting the U.S. as an export market for FOG. As a consequence, FOG consumption in Canada is likely to decline over time, increasing potential FOG supplies available for export to the U.S.

Increased supply of ICO (and sorghum oil) is expected to directly benefit the biodiesel market. Demand for fats and oils for use as a component of animal feed is already being met by other waste greases and oils, and any substitution for these feedstocks will result in a net increase available to biodiesel that is equal to the ICO increase. Consequently, additional growth in feedstock supply from ICO will largely be used for biodiesel production. The predicted growth in ICO volumes for biodiesel production amounts to a substantial 35 percent of the total increase in animal fat and waste grease supplies for biodiesel production between 2012 and 2022.

[41] John M. Urbanchuk. "Impact of Biodiesel on the Iowa Agricultural Economy" Study prepared for the Iowa Renewable Fuels Association. January 2013

Historically, the U.S. has exported approximately one third of FOG produced domestically. However, with the growth in the biodiesel industry over the past five years, FOG exports have declined to approximately 22 percent of production. This trend is expected to continue, leaving more pounds of FOG available for the domestic production of value-added products such as biodiesel. Growth in demand for these products in livestock, poultry, and aquaculture feeds, and industrial uses is expected to be relatively slow over the next decade. Reflecting these larger supplies, more feedstocks are expected to be available for biodiesel production. Total production of animal fats and waste grease and inedible plant oils is projected to increase by more than 50 percent between 2012 and 2022, reaching 19.4 billion pounds.

According to the EIA, FOG accounted for approximately 30 percent of biodiesel feedstocks in 2011 and nearly 34 percent in 2012. As a result of increased availability and slower growth in feed and industrial uses, we expect the share of these feedstocks available for biodiesel to increase from approximately 34 percent to 58 percent and be sufficient by themselves to produce nearly 1.5 billion gallons of biodiesel by 2022.

APPENDIX I

U.S.DATA

ASSUMPTIONS

	Cattle/Calf Slaughter (Mil Hd)	Hog Slaughter (Mil Hd)	Broiler Production (Mil Lbs)	Per Capita Disposable Income (Mil 2005$)	Personal Consumption Expenditures (Mil 2005$)	Food Expenditures (Mil 2005$)	Mid-Year Population (Million)
1991	35.3	80.5	18,430	23,442			253.5
1992	34.4	83.7	19,591	23,947			256.9
1993	34.5	90.0	20,904	24,033			260.3
1994	34.7	88.4	22,015	24,505			263.5
1995	35.7	90.8	23,666	24,939	6,076	548	266.6
1996	37.3	91.7	24,827	25,463	6,288	554	269.7
1997	38.6	88.2	26,124	26,049	6,520	559	273.0
1998	38.1	88.4	27,041	27,287	6,862	566	276.2
1999	37.1	97.0	27,612	27,792	7,238	587	279.3
2000	37.6	97.7	29,468	28,888	7,605	601	282.4
2001	37.6	94.6	30,209	29,297	7,810	608	285.2
2002	36.6	94.6	30,938	29,981	8,018	609	288.0
2003	37.0	96.8	31,895	30,453	8,245	617	290.6
2004	36.7	97.4	32,399	31,211	8,516	624	293.3
2005	33.8	99.9	33,699	31,343	8,804	645	296.0
2006	33.3	100.2	34,986	32,303	9,055	663	298.8
2007	34.6	101.1	35,120	32,749	9,263	673	301.7
2008	35.2	105.3	35,772	33,229	9,212	666	304.5
2009	35.5	112.5	36,511	32,016	9,033	655	307.2
2010	34.5	109.9	35,131	32,335	9,196	669	309.8

Source: USDA/NASS; Bureau of Economic Analysis

APPENDIX II

U.S.ANIMAL FATS AND WASTE GREASE PRODUCTION DATA

	Edible Tallow (Mil lbs)	Inedible Tallow (Mil lbs)	Yellow & Other Grease (Mil lbs)	Yellow Grease Per Capita (lbs)	Lard (Mil lbs)	Poultry Fat (Mil lbs)	Total (Mil lbs)
1991	1,251.3	3,680.6	2,027.9	8.0	513.7		7,473.5
1992	1,526.8	3,535.8	2,211.6	8.6	615.9		7,890.1
1993	1,425.2	3,888.6	2,710.7	10.4	588.7		8,613.2
1994	1,557.2	3,711.3	2,959.0	11.2	588.9		8,816.4
1995	1,536.3	3,754.3	2,947.4	11.1	612.7		8,850.7
1996	1,519.6	3,566.3	2,762.6	10.2	548.6		8,397.1
1997	1,488.1	3,504.4	2,706.6	9.9	471.2		8,170.3
1998	1,536.8	3,611.6	2,927.6	10.6	544.3		8,620.3
1999	1,729.3	3,859.1	3,171.8	11.4	535.9		9,296.1
2000	1,824.9	3,673.4	2,613.4	9.3	394.9		8,515.8
2001	1,791.8	3,448.6	2,482.2	8.7	270.7		8,001.9
2002	1,974.1	3,689.5	2,772.1	9.6	261.8		8,707.2
2003	1,965.8	3,703.6	2,541.3	8.7	250.5	889.2	9,359.3
2004	1,817.8	3,703.5	2,666.6	9.1	261.8	1,036.4	9,495.2
2005	1,812.5	3,877.5	2,680.2	9.1	266.9	1,181.0	9,827.1
2006	1,861.4	3,831.1	2,703.0	9.0	317.2	1,285.3	10,007.0
2007	1,788.9	3,808.5	2,819.8	9.3	465.7	1,377.5	10,269.7
2008	1,793.8	3,550.9	2,800.4	9.2	490.8	1,453.4	10,098.5
2009	1,837.3	3,375.6	2,844.9	9.3	346.1	1,378.8	9,792.0
2010	1,859.3	3,299.0	2,723.0	8.8	312.1	1,417.6	9,619.8

Source: U.S. Census Bureau Current Industrial Reports CIR M311K

	Biodiesel
2011	480.7
2012	545.8
2013	635.2
2014	727.1
2015	834.9
2016	918.8
2017	1,000.9
2018	1,086.9
2019	1,177.4
2020	1,271.9
2021	1,371.4
2022	1,476.4

	Production (Left)	(Right)
2008	376	0.32
2009	513	0.33
2010	640	0.34
2011	1,144	0.46
2012	1,792	0.55
2013	2,736	0.75
2014	3,477	0.85
2015	4,413	1.00
2016	4,785	1.05
2017	5,068	1.10
2018	5,367	1.16
2019	5,684	1.22
2020	6,018	1.28
2021	6,373	1.34
2022	6,748	1.41

	Exports
2007	3156
2008	3505
2009	2913
2010	3402
2011	2977
2012	2455